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PROGRESS REPORT ON THE BREEDING OF ABACÁ (*MUSA TEXTILIS* NÉE)

By J. P. TORRES and T. G. GARRIDO

Of the Bureau of Plant Industry

FIVE PLATES

Manila hemp or abacá, *Musa textilis* Née belongs to the genus Musa, family Musaceae, which is indigenous to the Philippines. This fiber plant has been in cultivation long before the white men discovered this country. The abacá fiber is an important contribution of the Philippines to the industrial world. Records show that at the time of Magellan's visit in Cebu in 1521, the weaving of abacá fiber was already widely spread in the Islands.(1) Copeland(2) also stated that, according to Dampier, the abacá was more or less extensively cultivated in Mindanao in 1686.

Past attempts to grow this plant in Florida, German East Africa, India, Indo-China, New Caledonia, Queensland and West Indies had invariably failed. Agriculturally speaking Java and Sumatra are far more advanced in many respects than the Philippines(2) and these two islands might in the near future take away from us our virtual monopoly of abacá fiber production. In fact, it is now believed that Borneo and Sumatra are gradually breaking the abacá monopoly of the Philippines. According to Alunan(3), Mr. H. T. Edwards, Fiber Expert of the U. S. Department of Agriculture and himself were not allowed by the Dutch Government to visit the abacá plantations

and factories in Sumatra. Obviously, the methods of abacá production in Sumatra are being kept secret by the Dutch Government.

The Philippines is now confronted with the problem of maintaining this abacá monopoly and placing the industry on a high level of efficiency. The solution seems to lie in the lowering of the cost of production, of which there are two important considerations. First, the general use of economical or labor-saving devices in the stripping of abacá fiber and second, the increase in production per unit area, which may be obtained by improved cultural methods and by the use of the superior strains that would give greater returns and fiber of a quality better than that of any of the existing varieties. It was with these things in mind that the breeding of abacá was instituted.

This paper gives a short history of the work in abacá breeding by the Philippine Government from 1906 to the present, the technique involved in the hybridization of abacá and the results so far obtained.

The main object of abacá breeding is to produce, determine and isolate new superior economic varieties in which high yield, good quality fiber and resistance to abacá bunchy-top and mosaic diseases, and other desirable characters are combined.

HISTORY OF ABACÁ BREEDING

Propagation of seed.—The earliest attempt in the Philippines to propagate abacá by seeds was made in 1906 in Lamao Experiment Station, Limay, Bataan Province. No promising strains from that planting have been isolated. The second attempt as cited by Labrador(4) was made in 1907 in La Carlota Experiment Station, La Carlota, Occidental Negros, and like the first trial, the results did not go further than to demonstrate the possibility of growing abacá from seeds.

In 1920, La Carlota Experiment Station planted again seeds of 22 different known varieties from Luzon and Mindanao and likewise, for some obvious reasons, no selection was made with these materials. Following this, in April, 1925 the former Guinobatan Abacá Experiment Station at Binogsakan, Guinobatan, Albay, grew seeds of the Tabaconon variety from Sorsogon, Sorsogon, from which some 200 seedlings were grown to maturity. The results of these studies showed that none of the seedlings were found superior to the old variety Tabaconon.

The fact that this plant is indigenous to this country and that there are at present many existing varieties or types which are not products of artificial hybridization, leaves no doubt that abacá seeds must in some way had been used as propagating materials in the early days. As far as the senior writer knows, while a youngster, he remembers that quantities of abacá seeds were ordered from Batangas to be grown in other places. In 1928 during the senior author's preliminary survey of abacá varieties in Albay and Sorsogon he was informed by some old abacá growers that abacá seeds were used in the early days in planting additional areas devoted to this crop. Some of the abacá plantations as claimed by some growers had existed for over 100 years without having been rejuvenated, and were found to consist of mixed varieties in a semi-wild state. The suckers and stocks of the most promising plants were gathered as planting materials for the development of the recently established plantations.

At Tiwi, Albay, the writer(5) with Mr. Pedro I. Cruz, Assistant Agronomist In Charge observed an interesting colored variety locally called *Ugarom.* In most respects this variety is very similar to the variety Itom which is commonly grown in Albay but the former is more vigorous and stocky with larger and taller stalks. According to an informant this *Ugarom* is a seedling progeny of Itom and is much more productive than the parent variety. The variety Ugarom deserves special attention to determine its merits and demerits in relation to abacá breeding work.

Hybridization.—The hybridization of abacá was once conducted in 1920 at La Carlota Experiment Station but the seeds obtained from the experiment did not germinate (reasons not stated) according to Labrador(4). Then in 1928 or about eight years later, crossing was done at the Guinobatan Abacá Experiment Station in Binogsakan, Guinobatan, Albay, by the senior author. In 1929 and 1930 the crossing experiments were performed by Mr. Pedro I. Cruz. The junior author did the hybridization work at Silang Abacá Disease Experiment Station, Silang, Cavite in 1931.

MATERIALS USED

In Guinobatan Abacá Experiment Station the following varieties were used: Itom, Lausigon, Maguindanao, Tañgoñgon,

Puti-tumatagacan, Bulao, Libutanay, Inisarog, and Canton. In Silang, Cavite, the varieties employed were the Putian, Jolo-tigasin,[1] Jolo-lambutin,[2] Maguindanao, Sinibuyas and the Kinalabao.

METHODS OF BREEDING AND TECHNIQUE OF HYBRIDIZATION

Like most other perennial crops that may be propagated by rootstocks and suckers, there are in the breeding improvement of abacá four general methods used namely, (*a*) mass selection, (*b*) pedigree selection, isolation of superior hills, (*c*) production of seedling varieties from naturally produced seeds, and (*d*) production of superior hybrid seedlings by artificial hybridization. The last two methods had proved, with various economic plants, to be most practical, and satisfactory results had been obtained in a relatively shorter time. Hence, the last two methods are being used with abacá, special attention being given to artificial hybridization.

The flowers and their behavior.—The female flowers are distinguishable from the male flowers in that the former have miniature nonfunctional and rudimentary male organs or staminate parts and occupy the basal half of the entire inflorescence while the male flowers have nonfunctional pistillate parts(6), plate 1, fig. 1. An observation of their arrangement in the inflorescence shows that the female flowers are first developed, followed by the middle sets of flowers that are neither female nor male and then by the male flowers, so that the male flowers begin to function long after all the female flowers of the same inflorescence have ceased to function, plate 1 fig. 2(*b*). Obviously, under natural conditions abacá is a crosspollinated plant. It must be noted, however, that intercluster pollination or pollination of the female flowers of one plant by the pollen grains from another plant of the same clone takes place in the plantation. Wasps, ants, bees, and other insects and small birds are constant visitors of the abacá flowers and are, therefore, agents of pollination. The pollen grains are produced abundantly.

Technique of hybridization.—Abacá hybridization as an art consisted of collecting the male flowers laden with pollen from the selected male parent plant and then placing the pollen on the stigma of the female flowers of the selected female parent plant. The stigma is in the receptive stage as soon as it exudes a mucilaginous substance (stigmatic fluid) which catches the

[1] Hard to strip. [2] Soft to strip.

pollen grain and offers favorable conditions for its germination. The receptiveness of the stigma may last two days or more. No sooner was it fertilized than it turned brownish within 24 hours and shrivelled and withered afterwards. The female flowers were kept in bag before and after the stigmas had dried off or lost their power of receiving pollen. To obviate any possible contamination of pollen grains intended for crosspollination it was necessary to bag the male flowers until they opened or became ready to be used.

The senior author collected some hearts or panicles of male flowers, wrapped them with Manila paper, and then placed them on the table under the shed. In the following morning it was observed that the first two to three bracts of male flowers had opened, with mature pollen grains. The pollen grains that were produced during seven consecutive days from 10 to 15 bracts of the same hearts were used in crosspollination work and were found as effective as those freshly collected pollen grains from the plants in the same morning. This experience merely shows that some of the pollen grains normally develop and mature in the hearts that had been severed from the mother plants and that there is the possibility of transporting abacá pollen for hybridization work some distance with the present transportation facilities.

Germination of seeds, care and selection of hybrid seedlings.— The seed flats were prepared out of halved empty petroleum boxes, figure 3, almost filled with garden or sandy loam soil which was previously sterilized by direct heating in empty petroleum cans placed over an oven. In some cases boiling water was poured directly into the prepared seed flats at the rate of about a petroleum can for every four seed flats. A more or less thorough soil sterilization by this method is obtained by repeating the process 24 hours after the first sterilization.

Seeds were extracted from ripe fruits, plate 2, figure 2, and were washed to remove as much as possible all adhering fleshy substances with great care so as not to press the seeds too hard and so as to avoid bruising the delicate embryo in the seed. The clean seeds were spread in the shade for a short while thus draining off all the excess water. Direct sun drying was found to be very pernicious to the vitality of the abacá seeds.

The abacá seeds were then sown at a depth of about 1 centimeter in the seed flat at the rate of about 200 seeds per flat.

At this rate of seeding the overcrowding of seedlings which results in spindling growth of plants is more or less avoided.

After germination the seed flats were transferred to partially shaded benches where they were watered daily and carefully by means of a hand spray pump which turned out water in very small drops or fine mist. While very young, abacá seedlings are quite delicate and are likely to be injured by water poured out of an ordinary sprinkler.

Soon after a large number of the seedlings had developed 4 to 5 small leaves or when the seedlings were about 6 to 8 centimeters high, plate 3, figure 1(*b*), the weak seedlings were rogued out and the more vigorous ones pricked and transferred into other seed flats or pricking flats at the rate of 48 seedlings per flat. In the seed flats or pricking flats, they were allowed to develop and grow to about 1 to 1½ feet high when they were ready for transplanting into the nursery beds.

At this stage only the most vigorous seedlings were selected and transplanted to the nursery bed, discarding all the undesirable and inferior seedlings. This selection was based on certain arbitrary standard with respect to size and vigor of the seedlings.

Nursery beds.—A nursery bed may be briefly described as a portion of the field, prepared for planting the seedlings as soon as they reach a height of about one and a half feet. In this bed the seedlings are set out closer than those in the permanent field, using various spacings such as in (*a*) rows one meter apart and hills 50 centimeters apart in the row; (*b*) in double rows with a distancing of 50 centimeters apart each way and 1 meter between the double rows; or (*c*) one and a half meters between the double rows and 75 centimeters to one meter between plants in the rows, plates 3 and 4, figure 2. The junior author used a distance of 18 inches each way between adjacent hills.

Initial clone plots and clone multiplication plots.—The seedlings were grown in the nursery beds for some time until a large number of them became ready for transplanting in the Initial Clone Plot for Individual Plant Selection Test. The most vigorous and free from disease seedlings were selected. In the Initial Clone Plot the hills were set 3 meters apart each way either in squares or quincunx, and therein allowed to develop as many suckers as possible. Here the relative height of individual clones, the number of suckers or stalks produced and

the tensile strength per gram-meter of the fiber were studied and taken as the basis for a preliminary selection of individual hybrids or Initial Clone Selection. The clones to be selected from the Initial Clone Plots were then transplanted to the Clone Multiplication Plots for further clonal selection work. To test the resistance of individual hybrids to bunchy-top and mosaic diseases some rootstocks and suckers were recently transferred to the Abacá Disease Experiment Station at Silang, Cavite for inoculation experiments in coöperation with the Plant Pathology Section of the Bureau.

RESULTS

The results of abacá hybridization may be presented in two sequences, namely, the results of 1928 to 1930 and those of the 1931 hybridization work. Chronologically speaking, those performed in Albay were 1 to 3 years earlier than those worked out in Silang, Cavite, but it will be seen later in the discussion of results that the 1931 crosses had already been planted in the Clone Multiplication Plots whereas the earlier crosses are as yet in the Initial Clone plots. As affected by the reorganization of the Bureau's technical personnel, the senior author was assigned in 1930 in Lamao Experiment Station; in Tanauan Citrus Station a year later and then in 1933 he was sent to the Economic Garden, as a plant breeder to work on the breeding of perennial crops other than fiber crops. In January, 1935, on the organization of the Plant Breeding Section he was recalled to Manila. The junior author was then assigned with the section but as there was no permanent government experiment station all abacá breeding work in Guinobatan and Moriones had to be held in abeyance from 1931 to 1938, awaiting the establishment of a government owned experiment station. Naturally, the abacá breeding work suffered a great loss of materials leaving only five of the 19 successful crosses which were planted in the Initial Clone Plots. Now that the Guinobatan Abacá Experiment Station has been established at Banao, Guinobatan, Albay, the clonal selection and propagation of abacá hybrids resulting from the earlier crosses will therefore be carried out.

The results of the 1928–1930 hybridization work at Guinobatan Abacá Experiment Station, Binogsakan, Guinobatan, Albay are shown in tables 1 and 2 and those of 1931 conducted in Silang, Cavite are presented in tables 3, 4, 5, and 6.

DISCUSSION OF RESULTS

Results of the 1928–1930 abacá hybridization.—Out of 27 different crosses made in Guinobatan Abacá Experiment Station there were eight failures and nineteen successful crosses. Crosses Nos. 16 and 17 failed because of the fact that the Canton is an sterile hybrid (plate 5, figs. 1 and 2) producing no pollen grain at all and it is believed that the internal cause of its failure to produce pollen grain or its impotence(7) may have similar effect upon the production of mature ova or egg cells; or the failure to effect fertilization may be due to the excessive length of the style of Canton or something in there that may inhibit the normal growth of the abacá pollen tube. Cases of this nature had been registered with various plants(7).

From the 19 successful Guinobatan abacá crosses, over 36,800 hybrid seedlings had been produced, about 11,000 of which had been pricked in the seed flat. This number gave in turn about 5,000 seedlings grown in the nursery beds representing only five of the successful crosses, namely, Itom × Lausigon, Itom × Maguindanao, Puti-tumatagacan × Maguindanao, Puti-tumatagacan × Lausigon, and Maguindanao × Lausigon. The four crosses, marked *M* in table 2 with a total of 2,039 hybrid seedlings, were planted in the Initial Clone Plot in 1930 and 1931 in Moriones Propagation Station, Pili, Camarines Sur and 585 hybrid seedlings of Maguindanao × Lausigon were transplanted on August 29, 1929 in the Initial Clone Plot in the Guinobatan Abacá Experiment Station, Binogsakan, Guinobatan, Albay. Obviously, the number of hybrid seedlings planted in the Initial Clone Plots represent only about 8.2 per cent of the total number of hybrid seedlings produced. This percentage should have been much more if the selection and transplanting had not been abandoned for reasons stated elsewhere in this report.

During the last visit of the senior author in April, 1938, the Initial Clone Plot in Moriones Propagation Station was in very poor shape, having been given very little or hardly any attention since it was established in 1931 and the weeds grew abundantly, and the plantation suffered from fire two times. It was also noted that the place because of its low altitude and more or less clayey soil where the plot was established is by far not particularly suitable for the growing of abacá. In spite of unsuitable soil conditions with almost complete neglect and calamities which befell the plantation there were found some 212 hybrid clones consisting of the four different crosses and rep-

TABLE 1.—*Different crosses and number of seedlings produced at Guinobatan Abacá Experiment Station, Binogsakan, Guinobatan, Albay.*

Cross number	Kind of crosses	Date started	1929	1930	1931	Total
1	Itom × Lausigon	10–15–28	4,918	1,600		6 518
2	Itom × Maguindanao	10 25–28	3 823	3,200		7 023
3	Maguindanao × Lausigon	10–18–28	3,032	480		3 512
4	Maguindanao × Tañgoñgon	11–11–28	486			486
5	Puti-tumatagacan × Maguindanao	11–18–29	2 017			2 017
6	Bulao × Lausigon	3–21–29	2 450	937		3 387
7	Bulao × Tañgoñgon	4–13–29	450	698	97	1,245
8	Bulao × Maguindanao	4–13–29	2,224	224		2 448
9	Lausigon × Tañgoñgon	4–20–29	200	895	256	1 351
10	Libutanay × Tañgoñgon	4–25–29	720			720
11	Puti-tumatagacan × Libutanay	4–26–29	684			684
12	Lausigon × Maguindanao	5–23–29	1 600	1 020		2 620
13	Itom × Tañgoñgon	4–10–29	1,040			1 040
14	Inisarog × Maguindanao	6–26–29		1 505		1 505
15	Puti-tumatagacan × Lausigon	6–28–29		1,071		1,071
16	Canton × Maguindanao	4–21–29	failure			failure
17	Canton × Tañgoñgon	4–30–29	failure			failure
18	Samina × Maguindanao	7–11–29	failure			failure
19	Amokid × Lausigon	9– 7–29	failure			failure
20	Samina × Amokid	10–20–29	failure			failure
21	Lausigon × Pacot	12–31–29	failure			failure
22	Lono × Alman	1–19–30	failure			failure
23	Alman × Maguindanao	1–23–30	failure			failure
24	Lausigon × Bulao	11– 2–30			698	698
25	Samina × Bulao	11– 5–30			329	329
26	Carnajon × Samina	11– 8–30			130	130
27	Inisarog × Samina	11– 9–30			50	50
	Total seedlings produced		23 644	11,630	1,560	36 834

TABLE 2.—*Different crosses and number of seedlings pricked and number planted in the nursery and in the Initial Clone Plots.*

Cross number	Kind of crosses	Total number of seedlings	Number of seedlings pricked	Number in nursery plots	Number of hybrids in Initial Clonal Plots
1	Itom × Lausigon	6 518	3,740	2,500	[a] 1,171
2	Itom × Maguindanao	7 023	1,490	930	[a] 662
3	Maguindanao × Lausigon	3 512	785	785	[b] 585
4	Maguindanao × Tañgoñgon	486	486	None	None
5	Puti-tumatagacan × Maguindanao	2 017	1 097	920	[a] 178
6	Bulao × Lausigon	3,387	2 125	[c]	[c]
7	Bulao × Tañgoñgon	1,245	450	[c]	[c]
8	Bulao × Maguindanao	2,448	[c]		
9	Lausigon × Tañgoñgon	1 351	200	[c]	
10	Libutanay × Tañgoñgon	720	720	[c]	
15	Puti-tumatagacan × Lausigon	1,071	[d]	[d]	[a] 28
	Total	29,778	11,093	5,135	2,624

[a] Planted in 1930 and 1931 in Moriones Propagation Station, Pili, Camarines Sur. Area 1.84 hectares.

[b] Planted, August, 1929 in Guinobatan Abacá Experiment Station, Binogsakan, Guinobatan, Albay. Area 0.44 hectar.

[c] All discarded.

[d] No record.

resenting 10.4 per cent of the original number of transplanted hybrid seedlings.

The Maguindanao × Lausigon cross in the Initial Clone Plot in Binogsakan was likewise almost completely neglected and therefore had a very poor stand. There were counted 85 living clones which represented about 15.2 per cent of the total number of seedlings transplanted on August 29, 1929.

Apparently, many of the surviving clones in the two breeding plots may be regarded as inherently resistant to insufficient care. Some of the clones in these two breeding plots in Moriones and Binogsakan appear to be of superior types and, needless to state, they should receive the much needed attention and support in order to expedite their selection and multiplication for subsequent distribution.

TABLE 3.—*Results of 1931 abacá hybridization work at Silang Abacá Disease Experiment Station, Cavite.*

Cross number	Kind of crosses	Date crossed	Number of bunches crossed	Number of bunches successfully crossed	Remarks
28	Maguindanao × Putian	12–5–31	4	4	
29	Putian × Maguindanao	12–5–31	2	2	
30	Putian × Kinalabao	12–3–31	2	2	
31	Kinalabao × Putian	12–3–31	2	1	
32	Putian × Jolo-tigasin	12–5–31	2	1	
33	Jolo-tigasin × Putian	12–5–31	1	0	Failure.
34	Putian × Jolo-lambutin	12–5–31	2	1	
35	Jolo-lambutin × Putian	12–5–31	2	2	
36	Maguindanao × Kinalabao	12–8–31	2	2	
37	Kinalabao × Maguindanao	12–8–31	2	0	Failure.
38	Maguindanao × Sinibuyas	12–9–31	4	0	Do.
39	Sinibuyas × Maguindanao	12–9–31	2	0	Do.
40	Putian × Sinibuyas	12–4–31	1	1	
41	Sinibuyas × Putian	12–4–31	1	1	
42	Punukan × Putian	12–5–31	2	1	Discarded.
43	Putian × Punukan	12–5–31	1	0	Failure.
44	Kinalabao × Sinibuyas	12–4–31	1	1	Discarded.
45	Sinibuyas × Kinalabao	12–4–31	1	1	Do.
46	Balunan × Punukan	12–9–31	1	0	Failure.
47	Punukan × Balunan	12–9–31	1	0	Do.
48	Tañgoñgon × Putian	12–9–31	1	0	Do.
49	Putian × Tañgoñgon	12–9–31	1	1	Discarded.
50	Canton × Kinalabao	12–3–31	2	0	No seeds produced.
51	Canton × Sinibuyas	12–3–31	2	0	Do.
52	Canton × Sinamoro-puti	12–4–31	2	0	Do.
53	Canton × Maguindanao	12–5–31	2	0	Do.
54	Canton × Putian	12–7–31	2	0	Do.

Be it stated in passing that the Maguindanao variety which was introduced from Davao about 13 years ago in the former Guinobatan Abacá Experiment Station, did not progress as it was completely destroyed by the several typhoons which, during the first five years, hit the station since it was planted in 1925. Presently, nowhere in that station could the original Maguindanao variety be found. Its susceptibility to wind or typhoons may be attributed to the poor or scanty root system. On the other hand, many of the Maguindanao hybrid seedlings in both the Moriones and Binogsakan breeding plots had proved quite vigorous, more prolific in producing suckers, and better adapted to lower altitudes and more or less superior for having much stronger root systems than the parent Maguindanao stocks. Indeed there are very good indications that the value of some of these Maguindanao hybrids to our abacá industry in the near future cannot at present be underestimated.

Results of 1931 hybridization.—Twenty seven different crosses, Nos. 28 to 54 inclusive, have been made, using 48 bunches as shown in table 3. Only 14 of the crosses came out successful with 21 successfully crossed bunches. The failure of the 5 Canton × Abacá crosses may be attributed to the same reason stated in the results of the 1928–1930 hybridization, i.e., sterility or impotence of the seed parent, Canton. Twelve of the abacá crosses also failed to produce bunches as they were destroyed by high winds before the maturity stage. Four of the abacá crosses, Nos. 42, 44, 45 and 49 which produced crossed bunches may also be considered failures because they produced nongerminable seeds for reasons not yet studied. Morphological studies of the embryo formation in such cases may throw some light as to the cause or causes of the production of nonviable seeds. Taking all the decided failures into account only 10 out of 27 different crosses may, therefore, be considered successful.

The 10 successful crosses gave in round number about 10,000 hybrid seeds which were grown in 1932 in the erstwhile Plant Pathology Laboratory at Pandacan, Manila. The selection of vigorous and healthy seedlings for nursery planting was also performed thus eliminating all the inferior and the weaklings. And, in November, 1932, some 1,500 abacá hybrid seedlings were selected and brought to the Economic Garden at Los Baños,

TABLE 4.—*Number of F_1 hybrid seedlings and suckers of parent varieties grown in the nursery plot, and Initial Clonal Plots in the Economic Garden and Mount Makiling.*

Cross number	Kind of crosses and parent varieties	No. F_1 hybrids selected in the nursery and number planted in the Initial Clone Plots			
		Nursery (1932)	Plot A, Economic Garden (1933)	Plot B, Mt Makiling (1933–34)	Total F_1 seedlings
28	Maguindanao × Putian	300	12	22	34
29	Putian × Maguindanao	100	[a]	11	11
30	Putian × Kinalabao	200	6	11	17
31	Kinalabao × Putian	150	6	[a]	6
32	Putian × Jolo-tigasin	300	[a]	59	59
34	Putian × Jolo-lambutin	100	[a]	12	12
35	Jolo-lambutin × Putian	100	6	[a]	6
36	Maguindanao × Kinalabao	100	2	39	41
40	Putian × Sinibuyas	50	[b]		
41	Sinibuyas × Putian	100	[b]		
	Putian (parent)		5	6	11
	Kinalabao (parent)		4	2	11
	Maguindanao (parent)		6	7	6
	Jolo-tigasin (parent)		3	12	12
	Jolo-lambutin (parent)		6	7	7
	Total F_1 hybrid seedlings	1,500	32	154	189

[a] None. [b] Discarded.

Laguna, and set out in the nursery plot 18 inches each way between hills. The number of seedlings of each of the different crosses is shown in table 4.

After about a year in the nursery a very careful selection was again performed, thus resulting in the isolation of 186 most vigorous hybrid seedlings, 32 of which were planted in October, 1933, in the Initial Clone Plots in the Economic Garden and 154 hybrids in December, 1933, and January, 1934 in Mount Makiling. Apparently, out of 1,500 seedlings grown in the nursery only 186 or 12.4 per cent were isolated, consisting of 34 of Maguindanao × Putian, 11 of Putian × Maguindanao, 17 of Putian × Kinalabao, 6 of Kinalabao × Putian, 59 of Putian × Jolo-tigasin, 12 of Putian × Jolo-lambutin, 6 of Jolo-lambutin × Putian, and 41 of Maguindanao × Kinalabao. The 150 hybrid seedlings from the crosses of Putian × Sinibuyas and its reciprocal cross were all discarded in view of their poor behavior in the nursery. The distance in the Initial Clone Plots was 3 meters each way.

The F_1 hybrids and the parent varieties were allowed to grow and multiply in the Initial Clone Plots for about 3 to 4 years

and then further selection was made, thereby giving consecutive clone number irrespective of the kind of crosses from which they were obtained. To date there have been selected out of 186 F_1 clones, 100 which were propagated in four Clone Multiplication Plots, and in the test plot for resistance to bunchy-top (see tables 5 and 6).

In the Clone Multiplication Plots the plants were set out 4 meters between rows and 4 meters between hills in the row so as to give ample space for the full development and suckering of the individual plants.

The Clone Multiplication Plot 1–EG which was established in September, 1937 in the Economic Garden contains 23 selected clones consisting of 575 hills or 25 hills per clone. The planting materials were all taken from the Initial Clone Plot A. The area of this Clone Multiplication Plot is about 9,600 square meters.

At about the same time the Clone Multiplication Plots Nos. 2 and 3 were established. All the planting materials used in these two plots were obtained from the Initial Clone Plot B in Mount Makiling. The 30 selected clones, Nos. 24 to 53, inclusive, consisted of 641 hills covering a total area of about 13,328 square meters which included one row of 18 hills of Putian (P_1) and 1 row of 22 hills of Maguindanao (M_1) parents. P_1 and M_1 refer to clonal lines of parent varieties.

The Clone Multiplication Plot No. 4 which was established in July, 1938 in the Economic Garden covers an area of about 14,100 square meters and contains 24 different hybrid clones comprising 544 hills and 12 parental clones of 247 hills. Summarizing, therefore, there are in these four Clone Multiplication Plots 73 selected hybrid clones of 1,750 hills and 14 parental clones comprising 287 hills. The total area of the four clonal multiplication plots is about 37,028 square meters or 3.7 hectares.

Study on the resistance of abacá hybrids to bunchy-top disease.—Studies on abacá hybrids resistant to one of the most important diseases of abacá such as the bunchy-top, has been and is being administratively relegated to the Plant Pathology Section due to lack of personnel and facilities in the Plant Breeding Section. This fact has to be mentioned here because plant breeding results, obviously, will remain incomplete until some resistant hybrid strains have been isolated. The interest of the breeders in this connection lies not merely in the selection

TABLE 5.—*Crosses and hybrids selected and parent varieties from the Initial Clone Plots and transplanted in the Clone Multiplication Plots.*[a]

Multiplication plot number	Cross number	Kind of crosses	No. F_1 hybrids or clones selected	Clone number	Row number	Total hills
1. Economic Garden	29	Maguindanao × Putian	A12–8	3–7 and 14–16	3–7 and 14–16	200
EG	30	Putian × Kinalabao	A 6–6	8, 9 and 17–20	8, 9 and 17–20	150
	31	Kinalabao × Putian	A 6–2	1 and 2	1 and 2	50
	35	Jolo-lambutin × Putian	A 6–5	10, 11 and 21–23	10, 11 and 21–23	125
	36	Maguindanao × Kinalabao	A 2–2	12 and 13	12 and 13	50
2. Mount Makiling	28	Maguindanao × Putian	B22–7	38–39	7–13	154
	29	Putian × Maguindanao	B11–2	40 and 41	15 and 16	36
	32	Putian × Jolo-tigasin	B59–3	24–26	1, 3 and 4	58
	36	Maguindanao × Kinalabao	B39–2	29 and 30	5 and 6	40
		Putian (parent)	B 6–1	P_1	2	18
		Maguindanao (parent)	B 7–1	M_1	14	22
3. Mount Makiling	29	Putian × Maguindanao	B –4	42–45	7–10	90
	30	Putian × Kinalabao	B11–6	46–51	11–16	141
	32	Putian × Jolo-tigasin	B –2	27 and 28	3 and4	42
	34	Putian × Jolo-lambutin	B12–2	52 and 53	5 and 6	42
	36	Maguindanao × Kinalabao	B –2	31 and 32	1 and 2	38
4. Economic Garden [b]	28	Maguindanao × Putian	A and B–6	14, 61–65	29, 5, 9, 18, 21 and 34	130
EG	29	Putian × Maguindanao	B –2	59 and 60	3 and 14	48
	30	Putian × Kinalabao	A –2	17 and 71	19 and 30	45
	31	Kinalabao × Putian	A –3	69, 70 and 2	17, 20 and 28	65
	32	Putian × Jolo-tigasin	B –5	54–58	1, 2, 6, 12 and 15	126
	35	Jolo-lambutin × Putian	A –3	72, 73 and 11	22, 31 and 32	65
	36	Maguindanao × Kinalabao	B –3	66–68	4, 8 and 10	75
		Maguindanao (parent)	–3	M2–M4	7, 23 and 25	68
		Jolo-lambutin	–2	J1–J2	11 and 16	47
		Jolo-tigasin	–3	T1–T3	13, 27 and 33	65
		Kinalabao	–2	K1 and K2	24 and 26	46
		Putian	–2	P2 and P3	35 and 36	21

[a] Multiplication plot Nos. 1, 2 and 3 were planted September, 1937 and plot No. 4 in July, 1938.
[b] Clones planted in Multiplication plot 4 EG, rows 1–16 were from Initial Clone Plot B in Mt. Makiling and those in rows 16–36 were from Initial Clone Plot A in the Economic Garden, Los Baños, Laguna.

TABLE 6.—*Abacá F_1 hybrids planted in November, 1938 in Silang Abacá Disease Experiment Station for disease-resistance studies.*[1]

Cross number	Kind of crosses or varieties	Clone number	Row number	Hill number	Total hills
29	Putian × Maguindanao	61	1	1–8	8
	Do	74	1	9–15	7
	Do	33	2	1–5	5
	Do	62	2	6–13	8
	Do	75	2	14–15	2
	Do	34	3	1–8	8
	Do	35	3	9–13	5
	Do	75	3	14–15	2
	Do	76	4	1–6	6
	Do	37	4	7–14	8
	Do	75	4	15	1
	Do	77	5	1–5	5
	Do	38	5	6–15	10
32	Putian × Jolo-tigasin	78	6	1–9	9
	Do	79	6	10–15	6
	Do	80	7	1–5	5
	Do	81	7	6–11	6
	Do	82	7	12–15	4
	Do	83	8	1–3	3
	Do	84	8	4–9	6
	Do	85	8	10–15	6
	Do	86	9	1–5	5
	Do	87	9	6–10	5
	Do	88	9	11–15	5
	Do	89	10	1–6	6
30	Putian × Kinalabao	90	10	7–14	8
	Do	91	11	1–8	8
	Jolo-tigasin (parent)	T4	11	9–15	7
32	Putian × Jolo-tigasin	92	12	1–15	15
34	Putian × Jolo-lambutin	93	13	1–15	15
	Do	94	14	1–6	6
36	Maguindanao × Kinalabao	95	14	7–12	6
	Do	96	14	13–15	3
	Do	96	15	1–3	3
	Do	97	15	4–9	6
	Do	98	15	10–15	6
	Do	98	16	1–9	9
	Do	99	16	10–15	6
	Do	100	17	1–10	10
	Do	67	17	11–15	5

[1] All F_1 hybrid clones in this plot were obtained from Initial Clone Plot B, in Mt. Makiling.

of varieties and production of hybrids but also in the testing of each of their individual selections for superiority, be it in yields, quality or in their reaction to natural enemies. Apparently, as mentioned above, the studies on hybrid strains resistant to bunchy-top disease are now in progress under the supervision of the Plant Pathology Section. The breeder's part in this connection is no more than to furnish materials for these studies.

The progress of these studies, while yet under our direction, is hereby reported.

Using the aphids, *Pentalonia nigronervosa* Coq. in the transmission of bunchy-top disease, inoculation test was conducted in August, 1936, in the two Initial Clone Plots, but 12 days after inoculation, all the inoculated plants were dug out by the order of the then Chief, Fiber Research Section, and the aphids were destroyed and killed by spraying them thoroughly with strong soap solution. Most of the plants and rootstocks in the inoculated hills were burned *in situ* and only 8 F_1 plants, each of Kinalabao × Putian, Maguindanao × Putian and Jolo-tigasin × Putian were saved and transferred to the Abacá Disease Experiment Station, Silang, Cavite, and planted on September 5, 1936. As of December 31, 1938 only three of the first cross, one each of the second and third crosses remained alive. The heavy mortality of hybrids in this planting was not due to the bunchy-top disease but due to very poor and too small planting materials coupled with the unfavorable weather conditions at planting time.

Were it carried out as planned by the senior author, obviously, we would at the present writing be in a better position to tell something on the relation of our abacá hybrids with the bunchy-top disease. Unfortunately, as it is now, because the former plan was somewhat modified by the Chief, Fiber Research Section, the resistance to bunchy-top of over 1,700 hills of hybrids in the multiplication plots is still doubted, and will remain so until each clone has been judiciously tried for bunchy-top resistance.

In October, 1938 another shipment to Silang Abacá Disease Experiment Station of abacá hybrids and parents was made, as may be seen in the following list:

Cross No.	Crosses and varieties	Clone No.	Number of plants
36	Maguindanao × Kinalabao	66	5
28	Maguindanao × Putian	61	5
32	Putian × Jolo–tigasin	58	6
	Jolo–tigasin (parent)	T_1	6
	Jolo–lambutin (parent)	J_1	4

The afore-mentioned materials were suspected of being affected by the bunchy-top disease in the Economic Garden so they were transferred and planted in Silang for further observation.

In November, 1938, another shipment to Silang Abacá Disease Experiment Station was made for the purpose of testing the resistance of the individual hybrid clones to bunchy-top disease of abacá. This collection consisted of 37 different hybrid clones and one parental clone, each cross numbering from 2 to 15 different clones with a total of 246 hills of hybrid forms. The hills were set 3 by 3.5 meters apart and the total area of the test plot was about 2,656 square meters.

All available crosses except cross No. 31, Kinalabao × Putian and cross No. 35, Jolo-lambutin × Putian, had been represented and of the 100 selected clones of the six different crosses only 39 clones were under disease-resistance tests, so there remained 61 clones yet to be subjected to inoculation test with bunchy-top disease and, as soon as possible, the suckers of each of these clones should be sent to Silang Abacá Disease Experiment Station.

At this juncture it is important to note that according to Calinisan and Hernandez(8) the Putian variety showed relatively high degree of resistance to bunchy-top disease. As a parent variety it is expected to produce resistant and superior hybrids when crossed with either the Maguindanao, the Tañgoñgon and other improved standard varieties.

Heterosis in abacá hybrids.—A preliminary study was made on the number of suckers produced by the individual hybrids in the Initial Clone Plots. The height of mature plants, basal, middle and top diameter, percentage and tensile strength of fiber had also been determined for comparison with the parent varieties. Any significant increase in these characters excepting perhaps in the last two characters of the hybrids as compared with the parents is believed to be due to the probable effect of heterosis. The data on the average number of suckers are presented in table 7, whereas, those of other characteristics studied will be presented in the next report on the studies of individual abacá crosses and hybrids for the selection of superior hybrid strains, a report which will also be published in this journal.

It can be seen in table 7 that the average number of suckers of F_1 hybrids of different crosses is in general larger than that of either parents or their corresponding averages and the percentage gain ranges from 46.7 to 85.1 per cent. Apparently, this general increase in the average number of suckers in the

TABLE 7.—*Comparison between parent abacá varieties and F_1 hybrids in the number of suckers produced*

Parent and crosses	Number of clones	Average number of suckers	Average F_1 minus average parents	
			Number of suckers	Per cent
Initial clonal plot A Economic Garden				
Maguindanao (parent)	6	14.0		
Putian (parent)	5	9.0		
Kinalabac (parent)	4	7.4		
Jolo-lambutin (parent)	6	12.4		
F_1 Maguindanao × Putian	12	20.4	8.9	77.4
F_1 Putian × Kinalabao	6	15.0	6.9	85.1
F_1 Jolo-lambutin × Putian	6	15.7	5.0	46.7
Initial clonal plot B Mount Makiling				
Putian	6	16.0		
Jolo-tigasin	12	13.0		
Maguindanao	7	11.0		
Kinalabao	2	8.4		
F_1 Putian × Jolo-tigasin	59	22.5	8.0	55.2
F_1 Putian × Kinalabao	11	19.0	6.8	55.7
F_1 Maguindanao × Putian	22	23.0	9.5	70.4

two Initial Clone Plots is due to hybrid vigor or heterosis in the F_1 generation.

SUMMARY AND CONCLUSIONS

This paper gives the history of abacá breeding since 1906 and the technique of abacá hybridization.

Of the 54 different crosses attempted from 1928 to 1931 only 29 crosses were successful, 19 crosses in Guinobatan Abacá Experiment Station, Binogsakan, Guinobatan, Albay and 10 crosses in Silang, Cavite.

Because of a shift in the Bureau's personnel, and because of failure to establish a government owned station until 1938, only 5 of the 1928–1930 crosses had been transplanted in the Initial Clone Plots. Those propagated in Moriones are the Itom × Lausigon, Itom × Maguindanao, Puti-tumatagacan × Maguindanao and Puti-tumatagacan × Lausigon and the only cross planted in the Binogsakan Initial Clone Plot is the Maguindanao × Lausigon. The superior seedlings that may be selected from the two breeding plots in Moriones and in Binogsakan should receive the much needed attention and support to facilitate propagation and subsequent distribution.

Eight of the 10 successful crosses among the 1931 crosses are at present in the Clone Multiplication Plots. Out of 186 clones in the Initial Clone Plots, 100 different clones had been selected. Of the 100 selected clones only 39 are under disease-resistance test at Silang Abacá Disease Experiment Station and 61 are as yet to be, as soon as possible, subjected to similar test. The four Clone Multiplication Plots cover an area of about 3.7 hectares while the disease-resistance test plot is about 0.3 hectare.

It was observed from the results of seven different matings that the Canton, a pollenless and seedless form of *Musa*, is cross-sterile with abacá using the latter as pollen parent.

Heterosis was observed in the F_1 hybrid of abacá crosses and its effect showed that the F_1 generation hybrids produced greater number of suckers than either parents, ranging from 46.7 to 85.1 per cent.

Compared with the Maguindanao parent variety the Maguindanao hybrids are better adapted to conditions and possess stronger root systems. Hence the value of the Maguindanao hybrids in the future abacá industry cannot at present be underestimated. It is hoped, however, that their hybrids with the Putian variety would be as resistant to bunchy-top disease as the Putian variety.

ACKNOWLEDGMENTS

The authors wish to express their appreciation to Mr. Pedro I. Cruz, assistant agronomist (of the former Guinobatan Abacá Experiment Station) who, in fact, performed the different experiments on crossing in 1929 and 1930 and grew the seeds and, together with Mr. Domingo S. Baybay, established the Initial Clone Plots in Moriones and in Binogsakan; to Mr. H. T. Edwards, technologist of the U. S. Department of Agriculture, who read the first draft of this progress report; and to the Acting Chief of the Fiber Research Section, Mr. Eladio Sablan, who gave this project his moral and material support.

BIBLIOGRAPHY

1. Brown, W. H. Minor Products of Philippine Forests 1 (1920) 364.
2. Copeland, E. B. Spanish work in agriculture in the Philippines. Phil. Agr. Rev. 1 (1908) 307–318.
3. Alunan, Rafael R. Agricultural Development in Southeastern Asia and Malaysia (1931) p. 14.

4. LABRADOR, A. F. The abacá project of La Carlota Experiment Station. Phil. Agr. Rev. 21 (1928) 3–19.
5. TORRES, J. P. Report on a trip to the Bicol region. Unpublished. Submitted May 11, 1938.
6. MENDIOLA, N. B. A Manual of Plant Breeding for the Tropics. Chap. 9 (1926) 189–204.
7. JONES, D. F. Genetics in Plant and Animal Improvement. Chap. 13 (1925) 252–405.
8. CALINISAN, M. R. and C. HERNANDEZ. Studies on the control of abacá bunchy-top with reference to varietal resistance. Phil. Jour. Agr. 7 (1936) 398–405.

ILLUSTRATIONS

PLATE 1

FIG. 1. Left, pistillate or female flowers; right, staminate or male flowers. Note the specialized parts of the two kinds of flowers.

2. (*a*) Right, newly opened heart with some pistillate flowers ready for pollination; (*b*) left, staminate flowers.

PLATE 2

FIG 1. Left, sterilized soil; middle, germinating abacá seeds; right, seedlings ready for nursery planting.

2. A hand of abacá fruits. Note seeds shown in the sections.

PLATE 3

FIG. 1. Abacá seedlings in different stages: (*a*) Very young seedlings; (*b*) at pricking stage; (*c*) not quite ready for nursery setting.

2. Partial view of the nursery showing some promising Itom × Lausigon seedlings.

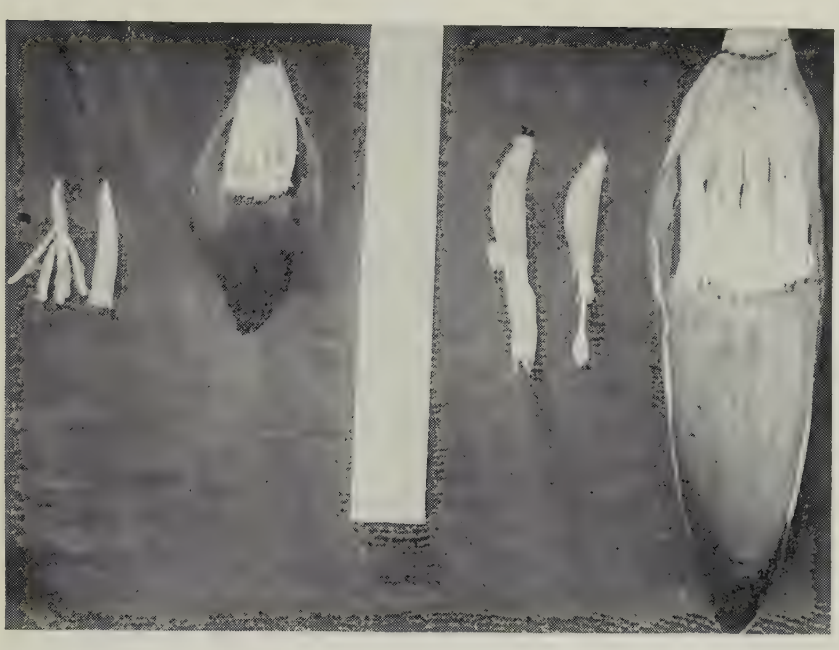
PLATE 4

Partial view of the abacá hybrid nursery in Binogsakan, Guinobatan, Albay, with seedlings of different abacá crosses.

PLATE 5

FIG. 1. A bunch of seedless Canton fruits.

2. A hand of Canton seedless fruits and sections showing absence of seeds.



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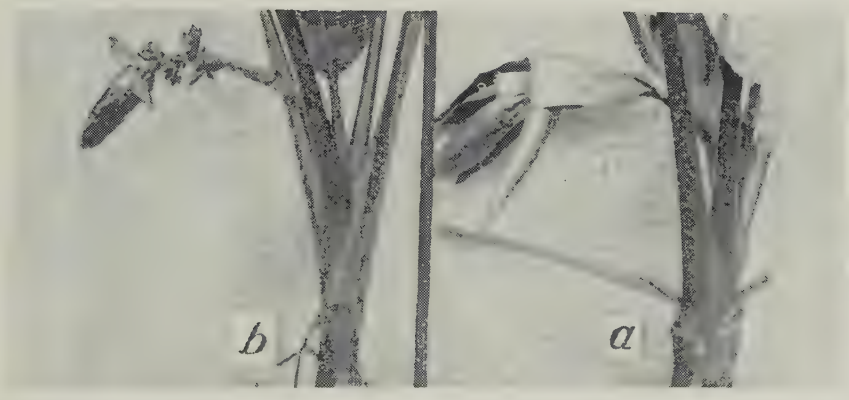

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PLATE 1.

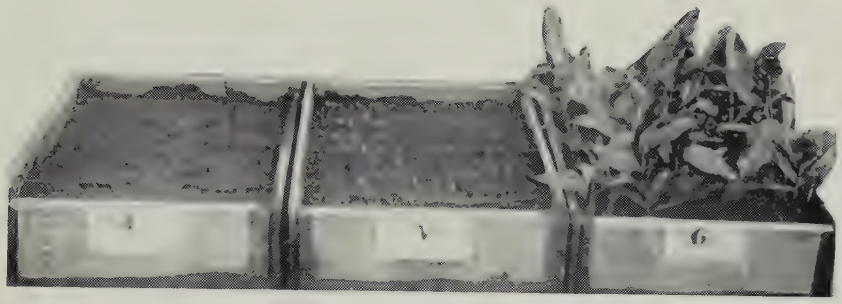

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PLATE 2.

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PLATE 3.

PLATE 4.

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PLATE 5.

RESULTS OF SISAL AND MAGUEY HYBRIDIZATION

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Of the Bureau of Plant Industry

THREE PLATES

Sisal, *Agave sisalana* Per., was introduced into the Philippines by the defunct Bureau of Agriculture in 1905 from Hawaii. It is commercially grown in Java, East Africa, India, and the Bahamas. Maguey, *Agave cantala* Roxb., on the other hand, was probably introduced into the Philippines by the Spaniards from Mexico and it has been grown here on a commercial scale since the early part of the nineteenth century. It is commercially grown also in Java and British India(1).

Since maguey, *A. cantala* Roxb., is one of the oldest fiber crops commercially grown in the Philippines, it is entitled to receive as much attention, in its improvement through hybridization followed by selection, as many other crops. Sisal, *A. sisalana* Per., has been introduced into the Islands some thirty-four years ago for experimental purposes. Each of these species of *Agave* possesses a number of desirable characteristics which should be combined through hybridization in order to create a superior variety.

So far, only two articles on *Agave* species are worthy of note as regards breeding. These are the work of Vidal(3) in Mayaguez, Porto Rico, and that of Doughty(4) on the study of chromosome behavior in relation to the genetics of *Agave*, at Cambridge, England.

This paper presents the technique and the results so far obtained from the hybridization of the two species of *Agave*, sisal and maguey and its reciprocal. Emphasis was given to the tensile strength and elasticity of the fiber from the parents

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and that from the first generation hybrid. For, according to Matthews(2), the tensile strength and elasticity are important properties of a textile fiber. Lack of these properties would make the fiber and its resulting products brittle and unyielding, thus, greatly limiting its field of usefulness in the manufacture of cordage.

REVIEW OF LITERATURE

In the Philippines, so far as the author is aware, no breeding work on *Agave* has been conducted previous to the work reported in the following pages. Dario(5) described at length the maguey industry in Ilocos Norte and Cruz(1) described four different species of commercial *Agave* and one ornamental type, compared their production and concluded that, of the five species studied, the ornamental type included, the maguey and sisal are the best two species from the commercial standpoint.

Vidal(3) made reciprocal crosses between sisal and henequen, *Agave fourcroydes* Lem., at Mayaguez, Porto Rico, and obtained negative results when sisal was used as the pistillate parent. In the cross of henequen × sisal, he obtained only 14 crossed seed pods from 300 cross-pollinated flowers. He also claimed that in Mayaguez the sisal produces only bulbils and never seed pods in its normal condition. On the other hand, Doughty(4) found out that *Agave* species were partially fertile and *A. sisalana* was so under certain conditions favoring effective pollination.

Jones(6) states that crossing somewhat different but related species of plants or animals usually results in a greater growth, manifested in the increase in size and sturdiness of the offspring. This condition is generally known as hybrid vigor or heterosis. He further states that the individual resulting from a cross is frequently stronger, grows larger, and is more resistant to unfavorable conditions. Jones et al.,(7) mentioned the fact that hybrid vigor is a temporary manifestation which ordinarily cannot be fixed and made permanent in sexually reproduced offspring. In this connection, Gutierrez(8) believes that continuous propagation of F_1 hybrid seedlings reproduced asexually will remain always in the first generation hybrids exhibiting the desirable hybrid vigor.

MATERIALS AND METHODS

The materials used in this hybridization work were the sisal, *Agave sisalana,* Per., and maguey, *Agave cantala* which were

grown in Lamao Horticultural Station, Limay, Bataan. Sisal has green, wide, and rigid leaves without marginal spines but with sharp pointed terminal spines. It produces white, coarse, and strong fibers. Maguey has grayish green, narrow, long and wavy leaves with sharp marginal and terminal spines. It produces white, fine, and long fibers, which are weaker in tensile strength than those of the former.

Flowers.—The flowers are large (fig. 1, plate 1). The six stamens may be easily removed by means of a forcep and the stigma is easily accessible (fig. 3, plate 1). The pollen grains are produced in abundance. The large sized flowerets and their suitable arrangement made hybridization work relatively easy.

Technique in hybridization.—The inflorescence stalks of both sisal and maguey are from 5 to 10 meters high. In order to insure successful operation in the making of crosses, a strong bamboo scaffold was built around the selected pistillate flower stalk. With the use of scaffold, the position, arrangement and the right stage of the flower cluster (fig. 1, plate 1) for emasculation had been determined at close range and this greatly facilitated the work(3).

Agave plants produce numerous flowerets so that it was easy to cross 500 flowers of sisal with maguey pollen and 500 of the reciprocal cross, that is, maguey × sisal. Emasculation was performed some 4 to 5 days before the flowers burst to send off the coil filaments holding the anther (fig. 2, plate 1), thus preventing the contamination of the stigmas by their own pollen grains. After emasculation (fig. 3, plate 1), the flowers were immediately bagged and four to five days thereafter the stigmas were well out and had become glossy due to the presence of a stigmatic fluid, indicating their receptiveness for the pollen grains. The pollen grains from the male flowers were then thoroughly dusted on the stigma. It was observed that the unpollinated stigma remained normal in appearance in 5 to 6 days more before it withered.

Cross pollination was started in January, 1932. After cross pollination the crossed flowers were covered again with bags and remained in such a condition until the pods became mature enough to be harvested. All the matured pods were harvested about the end of April, 1932, or four months after crossing. All the pods were broken into pieces in order to search for viable crossed seeds.

Growing of F_1 seeds.—The 12 seeds obtained from the crossed pods of the F_1 sisal × maguey were grown in pots at the

former Plant Pathology Laboratory, Pandacan, Manila. The soil was sterilized thoroughly by steaming in a petroleum can before placing it in the pots.

The seed was brownish white, more or less round and small, about one-half the size of a mongo seed. The pot was placed in a basin containing water to keep the soil in a saturated condition and a cheesecloth cover was placed so as to prevent the access of ants and other insects which might carry away or destroy the seeds.

Barely a month after sowing, four out of the 12 seeds germinated. The four tiny seedlings were attended to with utmost care. Despite precautions, however, three of the plantlets met natural death. Only one survived and continued to grow.

The leaves of the F_1 hybrid seedlings are of intermediate type, light green in color and are as rigid as those of sisal although some of the lower leaves are flapping down like those of maguey. Unlike the sisal, the leaves of the hybrids are not entirely devoid of marginal spines (figs. 1 and 2, plate 2). For brevity the lone F_1 sisal $\times$ maguey hybrid will be called F_1 Simag.[b]

In order to make a direct phenotypic comparison between the hybrid and its parents in their performance, some bulbils were also taken from each of the two parent plants and planted in pots; thus, the F_1 Simag hybrid seedling, and the sister bulbils obtained from the same mother plants were of about the same age. It must be stated that the bulbils are asexually reproduced from the rakishes of the long pole of the inflorescence.

Transplanting Simag hybrid and its parents.—When the Plant Pathology Laboratory at Pandacan, Manila, was closed about the middle of 1933, the potted Simag hybrid and parent seedlings were transferred in pots to the Central Experiment Station at Singalong, Manila. At 14 months of age, these seedlings were about 10 inches tall. They were then transplanted permanently along the fence one meter apart on the northern side of the Central Experiment Station. The hybrid and parent seedlings were thus given the same amount of care in watering, cultivation, and treatment, with practically the same soil and climatic conditions.

[b] "Simag" is a short name for the sisal $\times$ maguey hybrid.

Characters studied.—About the end of 1937 (4½ years from the date of transplanting) the leaves of both parents and hybrid were harvested and studied for: (1) the number, length, and weight of leaves; (2) the width of the leaves at the base, middle, and tip; (3) the percentage of clean dry fiber of the lower, middle, and upper leaves; and (4) the tensile strength and elasticity of the fiber.

The number of leaves represents the quantity of matured leaves comprising the harvest for the first year since this crop is usually harvested only once a year(5).

The length was determined from the base of the leaves to the base of the terminal "needle." The weights were taken immediately after harvesting the leaves, and the percentage of clean fiber was determined by the dry weight of clean fiber times 100 and divided by the weight of fresh leaves used in retting. The width of the base and tip were taken from the points two inches above the cut and two inches below the needle, respectively, and that of the center was taken from the widest portion, usually at the middle of the leaves.

Classification and retting of leaves.—Before harvesting F_1 Simag hybrid and the parent plants the three regional sections were first determined, to wit: (1) the lower or flapping leaves which formed an angle of 45° to 90° to the unfolded leaves; (2) the middle leaves which formed an angle of 30° to 45° to the unfolded leaves; and (3) the upper leaves which formed 0° to 30° to the unfolded leaves. The object of this regional leaf classification was to determine which class of leaves would give the largest percentage of retted clean fiber. The leaves were retted in a hole dug in the ground with water kept fresh all the time during the process.

Determination of tensile strength and elasticity of fibers.—The tensile strength and elasticity of the fiber were determined by means of a Louis Schopper tensile strength machine. The length of the fiber used was ⅓ meter. The formula employed in determining the tensile strength follows:

$$\frac{\text{Breaking strength in kilogram}}{\text{Weight of strand} \times 3} = \text{the tensile strength per gram-meter.}$$

The elasticity of the fiber was obtained by watching carefully the pointer move up the scale until the rupture of the fiber took place; the distance covered by the pointer represented the actual

stretch or the percentage of elasticity of the fiber as described by Matthews(2). The tests for tensile strength and elasticity were performed after the fiber had been uniformly dried under room temperature after about six months from the date of retting. In sampling the materials for the above determination, 16 trials were obtained from the class 1 or lower fiber, 18 trials from the class 2 or middle fiber and 16 trials from the class 3 or upper fiber, from the hybrid and parents, or 50 trials in every case, making a total of 150 trials in all. Thus, the above samples represented homogeneously the strength and elasticity of the fiber obtained from the different classes of leaves of each of the plants studied.

RESULTS

Out of the 500 flowers of sisal crossed with maguey only 12 or 2.4 per cent formed matured pods, each producing a seed. The percentage of successfully crossed pods was indeed very low. This result seems to confirm Doughty's(4) observation on sisal which, according to him, becomes partially fertile under certain conditions, but the negative results obtained by Vidal(3) when he used sisal as female parent and henequen as male parent may be attributed either to the less number of flowers employed or to the unfavorable conditions at the time of crossing.

All the results obtained are given in frequency distribution table Nos. 1 to 7, inclusive, which in turn were summarized in the last two tables, Nos. 8 and 9.

The F_1 Simag hybrid assumes an intermediate type between its two parents. It possesses some of the marginal prickles, the medium grayish green color of the leaves, the length and the flapping habit of the lower leaves of the maguey male parent and because of its vigorous condition, perhaps due to heterosis, its leaves are on the average wider and heavier than those of either parent.

Length of leaves.—It can be seen in table 9 that the leaves of maguey are longer than those of sisal with a significant difference of 6.15 ± 1.53 centimeters. The Simag, however, has a mean length greater by 5.58 ± 1.20 and 0.57 ± 1.12 centimeters than those of sisal and maguey, respectively. Apparently, it is significantly longer than sisal but nearly as long as maguey.

TABLE 1.—*Frequency distribution for the length of leaves of the F_1 Simag hybrid and parents.*

Variety or hybrid	Class value in centimeters										Total
	80	84.1	88.2	92.3	96.4	100.5	104.6	108.7	112.8	116.9	
Sisal	2		1	1	8	5	7	1			25
Maguey				1	6	7	2	2	2	5	25
F_1 Simag				2	3	3	7	10			25

M [1]	S. D. [2]	C. V. [3]
98 20±0.96	7.12±0 68	7 25±0.69
104 35±1.22	9 04±0.86	8.66±0.83
103.78±0.72	5.32±0.51	5.12±0.49

NOTE: [1] Mean. [2] Standard deviation. [3] Coefficient of variability.

TABLE 2.—*Frequency distribution for the width at the base of leaves of the F_1 Simag hybrid and parents.*

Variety or hybrid	Class value in centimeters										Total
	3	3.4	3.8	4.2	4.6	5.0	5.4	5.8	6.2	6.6	
Sisal					1	10	13	1			25
Maguey	5	16	4								25
F_1 Simag								4	18	3	25

M	S. D.	C. V.
5.22±0.05	0.35±0 03	6.65±0.63
3.38±0.04	0.30±0.03	8.87±0.85
6.18±0.04	0.32±0.03	5.11±0.49

TABLE 3.—*Frequency distribution for the width at the middle of leaves of the F_1 Simag hybrid and parents.*

Variety or hybrid	Class value in centimeters										Total
	6.0	6.5	7.0	7.5	8.0	8.5	9.0	9.5	10.0	10.5	
Sisal					2	1	3	8	5	6	25
Maguey	10	4	5	6							25
F_1 Simag								3	5	17	25

M	S. D.	C. V.
9.62±0.10	0.73±0.06	7.57±0.74
6.64±0.08	0.61±0.06	9.16±0.89
10.28±0.05	0.35±0.03	3.37±0.32

TABLE 4.—*Frequency distribution for the top width of leaves of the F_1 Simag hybrid and parents.*

Variety or hybrid	Class value in centimeters									Total
	3.0	3.3	3.6	3.9	4.2	4.5	4.8	5.1	5.4	
Sisal				5	9	8	1	1	1	25
Maguey	2		1	6	8	4	3	1		25
F_1 Simag			1	9	9	1	3		2	25

M	S. D.	C. V.
4.34±0.05	0.40±0.04	9.22±0.89
4.16±0.07	0.52±0.05	12.50±1.22
4.25±0.04	0.44±0.04	10.26±0.99

TABLE 5.—*Frequency distribution for the weight of leaves of the F_1 Simag hybrid and parents.*

Variety or hybrid	Class value in grams										Total
	137.0	177.1	217.2	257.3	297.4	337.5	377.6	417.7	457.8	497.9	
Sisal			1	4	4	15	1				25
Maguey	10	14	1								25
F_1 Simag							4	1	15	5	25

M	S. D.	C. V.
315.04±5.08	37.69±3.59	11.96±1.16
162.66±3.04	22.36±2.13	13.75±1.32
451.38±5.00	37.06±7.07	16.25±1.60

TABLE 6.—*Frequency distribution for the tensile strength of the fiber of the F_1 Simag hybrid and parents.*

Variety or hybrid	Class value per gram-meter in kilogram										Total
	10.5	12.0	13.5	15.0	16.5	18.0	19.5	21.0	22.5	24.0	
Sisal	2	2	6	9	6	10	3	7	3	2	50
Maguey	13	13	11	8	5						50
F_1 Simag	2	3	8	10	8	9	1	5		4	50

M	S. D.	C. V.
17.22±0.32	3.38±0.23	19.63±1.36
12.87±0.19	1.95±0.13	15.15±1.05
16.59±0.33	3.41±0.23	20.55±1.40

Basal, middle, and top widths of leaves.—A study of the data for basal widths as shown in table 9 will show that sisal has a wider base than maguey by 1.84 ± 0.06 centimeters but as compared with the Simag the mean differences are 0.96 ± 0.07 and 2.80 ± 0.06 centimeters over sisal and maguey, respectively.

With regard to middle width, shown in table 9, that of sisal is greater than that of maguey by 2.98 ± 0.13 centimeters. The mean basal width of 10.26 ± 0.05 centimeters of the Simag is greater than those of sisal and maguey by 0.66 ± 0.11 and 3.62 ± 0.09 centimeters, respectively. Hence the leaves of the Simag are significantly wider than those of either parent. As to the top widths of the leaves as shown in table 4, there are insignificant differences.

Weight of leaves.—There is a wide margin between the mean weights of fresh leaves of the parent varieties (table 5) as sisal gave 315.04 ± 5.08 grams and maguey, 162 ±3.04 grams, or a difference of 152.38 ± 5.92 grams. However, the Simag with a mean weight of 451.38 ± 5.00 grams has heavier leaves with mean differences of 116.34 ± 11.12 and 268.72 ± 10.34 grams over sisal and maguey, respectively. These differences are significantly large perhaps due to increase in size and weight as influenced by heterosis.

In this particular character the standard deviations are quite large, being 37.69 ± 3.59 grams for sisal, 22.36 ± 2.13 grams for maguey, and 37.06 ± 7.07 grams for the F_1 Simag with coefficients of variability of 11.96 ± 1.16, 13.75 ± 1.32 and 16.25 ± 1.60 per cent, respectively. These high coefficients of variability indicate that the materials used with respect to this character are not uniform and, therefore, the data indicate that 25 trials in every case are not sufficient. Nevertheless the differences in the means as pointed out are undoubtedly statistically significant.

Tensile strength and elasticity.—It has been stated that in the breeding experiment of fiber plants, emphasis is on the tensile strength and on the elasticity of the fiber produced. Upon these two characters mainly depends the usefulness of the fiber and consequently the durability and quality of the articles made from it. In table 6 it can be seen that the mean tensile strength of sisal is 17.22 ± 0.32 kilograms and that of maguey, 12.87 ± 0.19 kilograms, hence a difference of 4.35 ± 0.32 kilograms in favor of sisal, indicating that sisal fiber is significantly stronger than that of maguey. Compared with the F_1 Simag hybrid

having a tensile strength of 16.59 ± 0.33 kilograms the differences are 0.63 ± 0.45 and 3.72 ± 0.38 kilograms showing that the hybrid is nearly as strong as sisal but significantly stronger than maguey. The coefficient of variability of sisal is 19.63 ± 1.36 kilograms and that of maguey, 15.15 ± 1.05 kilograms. Hence, the coefficient of variability of the tensile strength of sisal fiber is greater by 4.48 ± 1.36 per cent than that of maguey, showing that there is a wider variation in sisal fiber than in that of maguey. The F_1 Simag with a deviation of 3.41 ± 0.23 kilogram and a coefficient of variability of 20.55 per cent has, therefore, the widest variation in tensile strength, although statistically it is almost as variable in its tensile strength as sisal fiber.

The elasticity.—Table 7 shows the elasticity of the fiber of the parents and their hybrid. Sisal gave 1.78 ± 0.05 per cent elasticity of fiber; maguey, 1.57 ± 0.04 per cent, or a difference of 0.21 ± 0.01 per cent, which is hardly significant. The mean difference between Simag, with an elasticity of 1.79 ± 0.04 per cent and sisal, is 0.01 ± 0.06 per cent; between Simag and maguey, 0.22 ± 0.06 per cent. The fiber of the F_1 Simag, therefore, is as pliable or elastic as that of sisal and slightly more so than that of maguey.

With respect to the coefficient of variability of elasticity of the fiber it is apparent that the parents as well as the resulting hybrid are almost equally variable but if the standard error is taken as the basis of measuring the significance of the results obtained as commonly used by some European workers(9), it is obvious that the pliability or elasticity of the F_1 Simag fiber depends on the syzygetic combination of the qualities of the parents.

Percentage of fiber.—The percentage of fiber in the three classes of leaves in sisal, maguey, and Simag hybrid taken as a whole, tends to increase, from the lower to the upper leaves. However, the increases or mean differences between regional classes of leaves as shown in table 8, are not at all statistically significant. Considering the mean percentages of fiber for each variety studied (table 8, column 10) and comparing them with each other, the differences are also insignificant.

It must be stated in this connection that the data presented are meager due to the very limited amount of materials available for study. However, this point will be more critically studied as soon as sufficient materials become available.

Yield of fiber.—The total yield for the first year harvest of a single plant was determined. The maguey plant produced the least amount of fiber, 172.0 grams, the sisal next, 274.3 grams, and the F_1 Simag gave 419.6 grams of clean fiber. Indeed, not much weight can be placed upon the yield data of a single plant. Nevertheless their relative value may be considered for reference and record purposes as the work is still in progress. Like the percentage of fiber, the yield will be more conclusively studied whenever practicable or as soon as sufficient materials shall have been produced.

TABLE 7.—*Frequency distribution for the elasticity of the fiber of the F_1 Simag hybrid and parents.*

Variety or hybrid	Class value in per cent										Total
	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.0	
Sisal	9	7	10	8	5	2	4	2	1	2	50
Maguey	14	13	6	4	5	3	3	2			50
F_1 Simag	8	9	7	6	8	5	3	2	1	1	50

M	S. D.	C. V.
1.78±0.05	0.49±0.03	27.53±1.99
1.57±0.04	0.40±0.03	25 48±1.82
1.79±0.04	0.46±0.03	25.71±1.84

TABLE 8.—*Fiber content of class 1, lower; class 2, middle; and class 3, upper leaves of the F_1 Simag hybrid and its parent varieties.*

Variety	Class 1			Class 2		
	Weight fresh (gms)	Clean weight (gms)	Fiber per cent	Weight fresh (gms)	Clean weight (gms)	Fiber per cent
Sisal	1,813	56.8	3.2	3,430	110.0	3.2
Maguey	1,484	51.3	3.4	1,480	53.0	3.6
F_1 Simag	3,542	118.0	3.3	3,815	132.4	3.5

Variety	Class 3			Mean of classes per cent	Total yield clean fiber (gms)
	Weight fresh (gms)	Clean weight (gms)	Fiber per cent		
Sisal	3,149	107.5	3.4	3.27±0.06	274.3
Maguey	1,644	67.7	4.1	3.70±0.20	172.0
F_1 Simag	4,341	169.2	3.9	3.57±0.17	419.6
Mean per cent of fiber for each class			3.30 ± 0.05	3.40 ± 0.12	3.80 ± 0.20

GENERAL DISCUSSION

A study of the data presented in table 9 will show that the two parent varieties differ greatly from each other in the characters studied. Sisal has shorter but wider leaves at the base and at the middle, heavier leaves and stronger fiber than maguey. As compared with sisal, the F_1 Simag hybrid possesses longer and slightly wider leaves at the base and at the middle and heavier leaves, but is almost equal to sisal as regards tensile strength and elasticity of the fiber. Compared with maguey, the leaves of the F_1 Simag hybrid are almost as long but are significantly wider at the base and at the middle and are much heavier, and its fiber is decidedly stronger and slightly more elastic. As regards top-widths of the leaves and percentage of fiber, Simag, sisal, and maguey are practically the same as the mean differences for these characters are very insignificant.

TABLE. 9.—*Summary of tables 1 to 7 inclusive comparing the means of the F_1 Simag, Agave hybrid with its parents, sisal (A. sisalana Per.) and maguey (A. cantala Roxb.)*

Characters	Sisal	Maguey	Difference between sisal and maguey	F_1 Simag
Mean length of leaves (cm.)	98.20±0.96	104.35±1.22	6.15±1.53	103.78±0.72
Mean basal width of leaves (cm.)	5.22±0.05	3.38±0.04	1.84±0.06	6.18±0.04
Mean middle width of leaves (cm.)	9.62±0.10	6.64±0.08	2.98±0.13	10.28±0.05
Mean top width of leaves (cm.)	4.34±0.05	4.16±0.07	0.18±0.09	4.25±0.04
Mean weight of fresh leaves (gms.)	315.04±5.08	162.66±3.04	152.38±5.92	451.38±5.00
Mean tensile strength of fiber (kgs.)	17.22±0.32	12.87±0.19	4.35±0.32	16.59±0.33
Mean elasticity of fiber (per cent)	1.78±0.05	1.57±0.04	0.21±0.06	1.79±0.04
Mean percentage of fiber from 3 classes	3.27±0.06	3.70±0.20	0.43±0.21	3.57±0.17

Characters	Difference (+ or —)		Increase over average of parents (per cent)
	Over sisal	Over maguey	
Mean length of leaves (cm.)	+ 5.58± 1.20	— 0.57± 1.12	2.5
Mean basal width of leaves (cm.)	+ 0.96± 0.07	+ 2.80± 0.06	43.7
Mean middle width of leaves (cm.)	+ 0.66± 0.11	+ 3.62± 0.09	26.4
Mean top width of leaves (cm.)	— 0.09± 0.07	+ 0.09± 0.07	0.0
Mean weight of fresh leaves (gms.)	+116.34±11.12	+268.72±10.34	88 9
Mean tensile strength of fiber (kgs.)	— 0.63± 0.45	+ 3.72± 0.38	10.2
Mean elasticity of fiber (per cent)	+ 0.01± 0.06	+ 0.22± 0.06	7.2
Mean percentage of fiber from 3 classes	+ 0.30± 0.54	— 0.13± 0.26	2.6

Comparing the average measurement of characters of the leaves of the two parent varieties and the F_1 Simag hybrid (table 9, column 7), excepting the top-width, the hybrid is either slightly or decidedly greater. It is 2.5 per cent longer, 43.7 per cent wider at the base, 26.4 per cent wider at the middle, 88.9 per cent heavier; and its fiber is 10.2 per cent greater in tensile strength, 7.2 per cent, in elasticity and 2.6 in mean percentage of fiber.

Propagation of the F_1 Simag.—As it usually takes about 6 to 7 years before sisal and maguey produce flowers and bulbils, it is expected that the resultant hybrid may produce bulbils after nearly as long a period. The propagation of the F_1 Simag hybrid is therefore limited to the production of suckers and rhizomes. Unfortunately, the lone F_1 Simag suffered from last year's flood which caused its natural death, but it had produced some 9 living suckers. Seven of them, together with some sisal and maguey suckers, were planted at the beginning of the rainy season of 1938 at the Commonwealth Farm, Muntinlupa, Rizal. These F_1 Simag suckers are given excellent care and all possible efforts will be exerted so as to multiply them as rapidly as possible.

At the present writing, the F_1 suckers on the Commonwealth Farm have just been observed to be growing very thriftily and evidently show the effect of hybrid vigor or heterosis as they appear far more vigorous than the suckers of the parent varieties that were planted at the same time. Such pronounced vigor of the F_1 suckers is to be expected because by asexual propagation, i.e., by planting suckers, rhizomes, and bulbils, the hybrid materials will always remain as hybrids exhibiting heterosis(8) unless altered by an unusual somatic mutation which, of course, very seldom occurs under normal conditions.

SUMMARY

Out of 500 sisal flowers crossed with maguey pollen only 12 seed-pods were produced, and not one seed-pod developed from 500 maguey flowers cross-pollinated with sisal pollen. These results indicate that crossing them is possible only in one direction because maguey does not produce seed-pod even though it produces abundant pollen grains. These results, therefore, confirmed the findings of Doughty(4) which showed that *A. sisalana* was partially fertile under certain conditions favoring effective pollination.

From the 12 crossed seeds produced, only 4 germinated and out of this number only one plantlet survived and continued to grow and gave nine F_1 suckers.

The F_1 hybrid, which is now named "Simag," a name derived from the contracted first syllables of the parent varieties, appeared more vigorous than either parent, an apparent effect of heterosis. It assumes a form intermediate between the two parents. It possesses some of the marginal prickles, waviness, flapping of mature leaves, the grayish green color and the length of leaves of the maguey male parent, and it also inherited from the sisal female parent the broad basal and middle portions of the leaves. The leaves are about intermediate in thickness.

The fiber of the F_1 Simag is decidedly stronger and slightly more elastic than that of maguey but is almost at par with that of sisal. In percentage of fiber, the three classes of leaves, the lower, the middle, and the upper are practically the same with slight tendency to decrease as the leaves become older. It may be stated that the F_1 Simag, sisal and maguey are practically the same as regards percentage of fiber. Nevertheless the meager data show somewhat greater amount of fiber produced by the F_1 Simag as compared with the two parent varieties.

The tensile strength, the yields, and the percentage of fiber should be further studied as soon as sufficient materials become available.

LITERATURE CITED

1. Cruz, E. E. A study of different species of *Agave*. Phil. Jour. Agr. 8 (1937) 1–3.
2. Matthews, J. M. The Textile Fibers. Their Physical, Microscopical and Chemical Properties. 1913. Third Edition, Rewritten: 1–13 and 253–259. New York: John Wiley and Sons, Inc.
3. Vidal, R. Breeding work with henequen and sisal. The Jour. of Heredity 16 (1925) 9–12.
4. Doughty, L. R. Chromosome behavior in relation to the genetics of *Agave*. Imperial Bureau of Plant Genetics Bull. 7 (1937) 143–144.
5. Dario, Leoncio. The maguey industry of Ilocos Norte. Phil. Agr. Rev. 21 (1928) 183–187.
6. Jones, D. F. Genetics in Plant and Animal Improvement. 1925. 266–291. New York: John Wiley and Sons, Inc.
7. ..... and P. C. Mangelsdorf. The improvement of naturally cross-pollinated plants by selection in self-fertilized lines. Conn. Agr. Expt. Sta. Bul. 266 (1925) 364–401.
8. Gutierrez, Mariano E. Plant-to-the-row tests on seedlings of strawberry. Phil. Jour. Agr. 9 (1938) 335–338.
9. Hayes, K. H., and R. J. Garber. Breeding Crop Plants. 1927. Second Edition: 10–14. New York: McGraw-Hill Book Co., Inc.

ILUSTRATIONS

Plate 1

Fig. 1. The flower cluster: (*a*) matured flowers almost ready to dehisce their pollen; (*b*) the right stage of the floweret for emasculation; and (c) young flowerets.

2. A floweret which was broken by forceps for emasculation before it burst to send off the coil filaments holding the anther.

3. Emasculated floweret ready for pollination.

Plate 2

Fig. 1. *Left,* the pistillate parent, sisal, *Agave sisalana.* Note the dark green, wide, and rigid leaves. *Right,* the staminate parent, maguey, *Agave cantala.* Note the flappy, grayish-green, narrow and long leaves. *Center,* the first generation Simag hybrid. Note the size of the plant which exhibits hybrid vigor. The wide leaves are intermediate light green and are as rigid as those of sisal although some of the lower leaves are flapping like those of maguey.

2. (1) Sisal leaf without marginal spines. (2) First generation Simag hybrid leaf, not entirely devoid of marginal spines. (3) Maguey leaf with pronounced marginal spines.

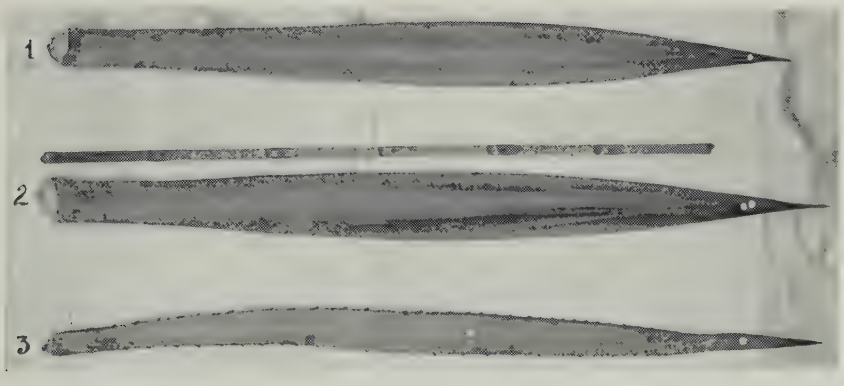
Plate 3

THE FIBERS

The first three at the left are fibers of sisal; the three at the right, those of maguey; the three at the middle, F_1 Simag. Numbers 1, 2, and 3 represent the fibers obtained from the lower, middle, and upper leaves, respectively.

PLATE 1.

1



2

PLATE 2.

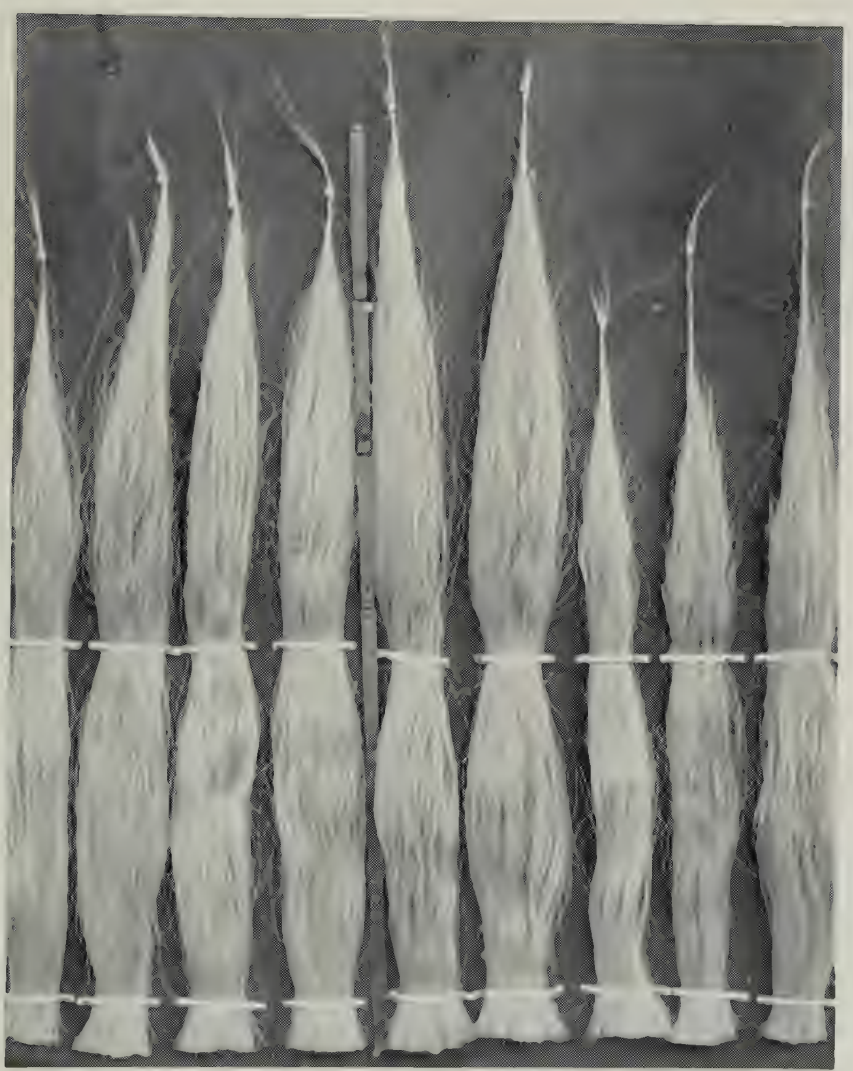


PLATE 3.

PLANT EXPLORATION AND INTRODUCTION WORK OF THE BUREAU OF PLANT INDUSTRY

By M. Manas y Cruz, *In Charge, Seed and Plant Introduction*
Fernando de los Reyes, *Assistant Agronomist*
and
Gregorio Godoy, *Junior Agronomist, Bureau of Plant Industry*

In an eminently agricultural country like the Philippines, the importance of plant exploration and introduction is self-evident. While the former concerns with the search for wild species of economic value for domestication purposes, the latter deals principally with the introduction of foreign plants of desirable qualities with the end in view of improving our cultivated crops. Thus, the little known regions of Mindanao and other sections of these Islands must be explored for humidity-loving plants; the Mountain Province, for subtropical species, etc. Moreover, plants of known economic value need to be introduced from abroad for acclimatization, propagation, and hybridization, if necessary. This short-cut method of improving our cultivated crop varieties and increasing the wealth and resources of our flora was started by the old Bureau of Agriculture in 1902 and carried on to the present time by the Bureau of Plant Industry.

Much of our seed and plant introduction work had been done by the personnel of the former Bureau of Agriculture, to wit: Mr. O. W. Barrett, who was responsible for the introduction of a big collection of bananas from the British East Indies, India and China, in 1911–1913; Mr. H. H. Boyle, who introduced the Siamese seedless pummelo from Siam, in 1912; the late Secretary Silverio P. Apostol, who introduced varieties of rice from Italy, Java, Japan, China and India, in 1919–1921; Mr. Domingo B. Paguirigan, who introduced varieties of tobacco from Sumatra, in 1925–1927; Mr. Francisco G. Galang, who introduced certain selected clones of Para rubber from Sumatra, in 1926; Prof. Harold Cuzner, who in 1904 made the first introduction of avocados in the forest reservation of the Government at Lamao, Bataan; and the late P. J. Wester, who devoted the best years of his life to plant introduction and exploration activities in these Islands and whose salient accomplishments are embodied

in Bulletin No. 39, entitled "The Food Plants of the Philippines." Besides, numerous species of exotic plants had also been introduced by the College of Agriculture, University of the Philippines, the Bureau of Forestry and the City Nurseries of Manila and Baguio.

In our introduction work, seed and plant materials are secured either through exchange with foreign experiment stations, public parks, government entities and private individuals, or by purchase from seed farms and nurseries abroad.

Up to 1937, the following introductions have been made:

Total number of species	953
Total number of varieties	7,049
Countries of origin	47

Directly traceable to the plant introduction work of the Bureau of Plant Industry, is the fact that at present we are successfully growing in these Islands a big number of such plant immigrants as citrus, avocado, caimito, tiessa, strawberry, onions, cabbages, cauliflower, tobacco, Para rubber, etc.

The following is the first part of an inventory of seed and plant introductions made by the Bureau of Plant Industry which will be published in series:

SUGAR CANE, *Saccharum officinarum* L. (GRAMINEAE)

P. I. No. 4910: P. O. J. 2878.—Introduced from Java through Dr. Bach in 1927. This is a well-known hybrid cane from Java, which occupies a considerable portion of our sugar-cane lands today. Its desirable qualities are heavy yield, good growth even on low heavy soils, and large, vigorous suckers. Undesirable qualities include juice of low purity, long growing period, slow ratoon growth, heavy tasseling, coming early in season with consequent pithy stalks, and inability to withstand winds. It is highly susceptible to the stem borer. This variety of cane should be planted early and harvested in 14 months. Yield per hectare: 71.30 tons of cane equivalent to 103.51 piculs of sugar. Grown by the Agricultural Service, Inc., La Granja, Occidental Negros (formerly La Granja Sugar Cane Experiment Station, Bureau of Plant Industry).

P. I. No. 8743: Badila.—Introduced from Australia in 1913. First grown in the La Carlota Sugar Cane Experiment Station, La Carlota, Occidental Negros. The Badila is a stout purple cane which grows erect and matures in 12 to 14 months after planting. Its sugar content is high. It grows best in fertile soils, either upland or lowland, and gives particularly good yield

when planted from September to December. Yield per hectare: 67.89 tons of cane equivalent to 132.57 piculs of sugar (sucrose, over 18 per cent, and 90 per cent juice purity). Being grown by the Agricultural Service, Inc., La Granja, Occidental Negros (formerly La Granja Sugar Cane Experiment Station, Bureau of Plant Industry.)

P. I. No. 9374: Mauritius—1900.—Received from Pampanga Sugar Mills, Del Carmen, Pampanga in 1926. Sent to the La Carlota Sugar Cane Experiment Station, La Carlota, Occidental Negros. This variety has acquired some degree of importance in Luzon where it is grown on all kinds of soils. On sandy and poor clay soils it grows erect and stools slightly but may suffer from extreme droughts. On fertile soils or good clay loams, the cane may be prostrate, but the yield is heavy. The color varies according to the amount of exposure, from faint reddish violet to deep violet. Growth is easily affected by drought, disease and insect pests. Yield per hectare: 59.45 tons of cane equivalent to 102.34 piculs of sugar. Being grown by the Agricultural Service Inc., La Granja, Occidental Negros (formerly La Granja Sugar Cane Experiment Station, Bureau of Plant Industry, La Granja, Occidental Negros).

P. I. No. 10365: Barbados 147.—Introduced from Buitenzorg, Java, in 1919. This is a yellow medium-sized cane with a propensity to recline when nearly mature. It grows well in poor soil and is able to resist mosaic and Fiji diseases. It matures in 12 to 14 months. Suitable for small mills on account of its size and soft tissue. A good chewing cane. Yield per hectare: 81.41 tons of cane equivalent to 134.34 piculs of sugar. Formerly grown at the La Carlota Sugar Cane Experiment Station, La Carlota, Occidental Negros.

P. I. No. 10366: D. I. 52.—Introduced from Proefstation, Pasoeroean, Java, in 1919. Sent to the La Carlota Sugar Cane Experiment Station, La Carlota, Occidental Negros. It is an early variety well adapted to grinding in small mills for the production of muscovado sugar. It can be harvested in 10 months when planted early, as in October or November. The cane is purplish and is erect in growth. It is good for chewing purposes. Yield per hectare: 68.77 tons of cane equivalent to 129.64 piculs of sugar.

P. I. No. 10381: P. S. A. 14.—From the Philippine Sugar Association, Manila. Received in 1931 and sent to the La Granja Sugar Cane Experiment Station, La Granja, Occidental Negros. This is a cross between PB–119 and CAC–82. The

cane matures early, is erect, and is greenish purple. It is hardy against wind and is practically immune to diseases. The sugar content is high. In recent years (1934–1935), this variety yielded more sugar than any other variety in Luzon. Yield per hectare: 68.15 tons of cane equivalent to 134.94 piculs of sugar. Being grown by the Lipa Coffee–Citrus Station and the Agricultural Service, Inc. (formerly La Granja Sugar Cane Experiment Station, Bureau of Plant Industry).

P. I. No. 10382: Alunan cane (*L. C. 25/191*).—This is a cross developed by the Bureau between the Badila and the Java 247. It gives heavy yields of sugar in the soils of central Occidental Negros, where in 1936, approximately one-fifth of the total cane areas was planted to it. It grows rapidly and matures in about 12 months. Half-matured stalks may be cut and planted in the months of September and October. Yield per hectare: 90.80 tons of cane equivalent to 180.04 piculs of sugar. Being grown by the Agricultural Service, Inc., La Granja, Occidental Negros (formerly La Granja Sugar Cane Experiment Station, Bureau of Plant Industry).

FORAGE GRASSES (GRAMINEAE)

P. I. No. 5488: Napier grass, Pennisetum purpureum Schum.—A tall, erect, perennial, and coarse grass attaining a height of about 2.5 to 4 meters. Leaf about 70 centimeters long and 1.5 to 2 centimeters broad, hairy at the base and on both surfaces; stalk, similar to that of the Uba cane but smaller, spongy, and with a hollow stem; flower, like a cat's tail, brownish in color with very fine seeds. A native of tropical Africa, introduced from Hawaii in 1916. Yields about 93,000 kilos of green forage per hectare a year. Relished by animals when cut every twenty days. Formerly grown at the Lamao Experiment Station, Lamao, Bataan. Analysis: moisture 83.32 per cent; protein, 1.6 per cent; crude fiber, 5.64 per cent; fat, 0.59 per cent; and carbohydrates, 6.61 per cent.

P. I. No. 266: Dallis grass, Paspalum dilatatum Poir.—Introduced from Australia in 1907 and sent to the Lamao Experiment Station, Lamao, Bataan. A perennial pasture grass attaining a height of about 50 to 70 centimeters. Leaves, short and narrow, 28 centimeters long and 1.2 centimeters wide; edges, catchy; surface, smooth. Flower in head with from 3 to 4 spikelets, arranged alternately on the flower stalk. Stigma, dark purple. Yields about 26,000 kilos of green forage per

hectare a year. Relished by stock when cut every twenty days. Formerly grown at the Lamao Experiment Station, Lamao, Bataan. Analysis: moisture, 66.0 per cent; protein, 1.8 per cent; ash, 3.2 per cent; crude fiber, 26.9 per cent; fat, 0.9 per cent; and carbohydrates, 1.2 per cent.

P. I. No. 302: Cayenne grass, Unidentified sp.—Introduced from Ventimiglia, Italy, on August 29, 1914. Grown for the first time at the Singalong Experiment Station, Bureau of Agriculture, Manila. A perennial creeping grass. Roots develop from every joint that touches the ground; leaves, about 54.5 centimeters long and 2.4 centimeters broad; edges and upper surface of the leaf, rough; lower surface, smooth. Leaf sheath, purplish in color and covered with many long stiff hairs. Stalk, spongy inside; internode, from 8 to 12 centimeters long.

P. I. No. 321: Para grass, Panicum barbinode Trin.—Introduced in 1910 from Ceylon. A coarse, perennial, creeping grass attaining a height of from 1 to 2 meters under favorable conditions. Stem becomes erect when the plants are crowded. Leaf dagger-shaped with short butts; 17.5 centimeters long and 1.5 centimeters wide; edges raspy, smooth on both surfaces. Leaf sheath, covered with colorless hairs. Stalk, slender and hollow; internode, about 8.5 to 10 centimeters long. Roots are formed on every joint touching the soil and are fibrous. Flowers, spike-like racemes arranged opposite each other. In moist ground Para may even check cogon. A native of South America. It yields in one year about 29,000 kilos of green forage per hectare. Relished by stock when cut every twenty days. Grown for the first time at the Singalong Experiment Station, Bureau of Agriculture, Manila. Analysis: moisture, 70.44 per cent; protein, 1.63 per cent; fat, 0.48 per cent; ash, 1.96 per cent; and carbohydrates, 25.49 per cent.

P. I. No. 1590: Teosinte, Euchlaena mexicana Schrad.—Introduced from Sydney, Australia, in 1908. Grown for the first time at the Singalong Experiment Station, Bureau of Agriculture, Manila. This can be grown successfully and makes an excellent forage, being very succulent and a heavy yielder and producer of good seeds. It cures out more like corn. It does better at sea level than at higher altitudes, but will not stand drought. It yields 62,313 kilos of forage per hectare after 141 days. On good fertile soil and with plenty of water, teosinte will produce a heavier yield of very succulent green feed than Guinea grass.

P. I. No. 1819: Guinea grass, Panicum maximum Jacq.—A native of tropical Africa, introduced into the Philippines in 1907 from Hawaii. An erect, rather coarse, and perennial grass, about a meter or more high and with long and narrow leaves. Edges, base, and upper surface of leaves hairy, lower surface purplish and smooth. Stalk, slender and fibrous but spongy at the center. Flower in head composed of circle of spikelets formed of individual small flowers. Stigma purple. Yields about 53,000 kilos of green forage per hectare a year. Relished by animals when cut every twenty days. Formerly grown at the Lamao Experiment Station, Lamao, Bataan. Analysis: moisture, 71.5 per cent; protein, 1.2 per cent; ash, 2.2 per cent; crude fiber, 10.9 per cent; fat, 0.7 per cent; and carbohydrates, 12.1 per cent.

P. I. No. 2192: Merker grass, Pennisetum merkerii Schum.—Introduced at the Lamao Experiment Station, Lamao, Bataan, from Davao, Mindanao, in 1912. An erect, tall, perennial grass resembling Napier in all respects except that the leaves are longer and narrower and the stalk more slender, with tiny hairs about the base and fibrous tissues inside. Edges and upper surface, rough; lower surface, smooth. Flowers, brownish and borne in spikes.

P. I. No. 6933: Guatemala grass, Tripsacum laxum Nées.—A tall, erect, perennial grass very much resembling corn at a distance, except that it has short stalks. Leaves, about 90 centimeters long and 5.7 centimeters broad; raspy edges with a tinge of purple; upper surface, rough and lower, smooth; leaf sheath, pinkish to purplish; stalk, flattened and almost covered by leaf-sheath. This grass was received on April 11, 1919 from the U. S. Department of Agriculture, Washington, D. C., U. S. A. Yields about 36.500 kilos of green forage per hectare a year. Relished by animals when cut every sixty days. Grown for the first time at the Singalong Experiment Station, Bureau of Agriculture, Manila.

P. I. No. 8788: Uba cane, Saccharum officinarum L.—Collected and grown at the Lamao Experiment Station, Lamao, Bataan, in April, 1911. Grown for the first time at the La Carlota Sugar Cane Experiment Station, La Carlota, Occidental Negros. The leaf of this cane makes a good forage. Cane, slender with long narrow leaves; leaf base, hairy. Flowers, similar to those of sugar cane. Some people use this variety as a source of sugar, it being hardy and resistant to various diseases of the sugar

cane, although less juicy. It yields in one year about 56,600 kilos of green forage per hectare. Relished by stock when cut at the age of ninety days. Analysis (dry basis) : moisture, 6.75 per cent; protein, 1.37 per cent; fat, 1.89 per cent; ash, 2.04 per cent; crude fiber, 26.6 per cent; and carbohydrates, 67.35 per cent.

P. I. No. 13775: Buñgalon grass, Homalocenchus hexandrus Pers.—A perennial creeping native grass commonly cultivated around Manila. Leaves about 32.5 centimeters long and 1.2 centimeters broad with trichomes at the base. Base of leaf sheath which surrounds the nodes, covered with fine hairs: leaf, hairy at the edges and on upper surface, and smooth on the nether surface. Stalk grows erect when the plants become crowded; internode varies from 6.5 to 10 centimeters long; roots spring from every node that touches the ground. Internal part of the stalk has fibers like cotton threads attached to it at the center. Yields about 12,000 kilos of green forage per hectare a year. Relished by animals when cut about 90 days old. Introduced from Iloilo, Iloilo, in 1926 at the Lamao Experiment Station, Lamao, Bataan.

P. I. No. 8982: Sudan grass, Holcus halepensis L.—Introduced at the Lamao Experiment Station, Lamao, Bataan, from Washington, D. C., in 1925. A tall perennial grass with fine leafy steams, the largest stalk seldom larger than a lead pencil; panicles, loose and open and pyramidal in form. It yields approximately 20,000 kilos of green forage per hectare annually; forage or hay, slightly coarse, but quite palatable if cut or pastured on before seed formation. It makes a good soiling crop for native cattle and carabaos. Analysis (dry basis) : protein, 4.43 per cent; fat, 2.92 per cent; crude fiber, 36.82 per cent; ash, 9.63 per cent; and carbohydrates, 46.2 per cent.

PEANUTS, *Arachis hypogaea* L. (LEGUMINOSAE)

P. I. No. 8304: Tennessee Red.—Introduced from New Orleans, Louisiana, U. S. A., on March 17, 1923. This variety exhibits a vigorous upright growth. The pods which form at the base of the plant are long and slender with three to four kernels of bright red color. The shell is thin. This peanut matures in from 105 to 125 days, and yields about 12 cavans of shelled nuts per hectare. This variety is generally used for roasting purposes. Formerly grown at the Lamao Experiment Station, Lamao, Bataan.

P. I. No. 10072: Virginia Runner.—Introduced from Texas, U. S. A., on March 3, 1929. This variety has a spreading habit of growth, which makes it rather hard to cultivate and to harvest. Large podded variety; strong grower; stems, creeping; foliage, heavy; pods, scattered along procumbent stems; pods and peas, very similar to those of Virginia Bunch; pods do not adhere well to the plant upon digging. It matures in from 165 to 185 days, and yields about 14 cavans of shelled nuts per hectare. Formerly grown at the Lamao Experiment Station, Lamao, Bataan.

P. I. No. 10073: Virginia Bunch.—Introduced from Texas, U. S. A., on March 1, 1929. The pods of this variety are very similar to those of Virginia Runner; plant, rather dwarf; stems, upright; foliage, rather light; pods, clustered about the base of the plant, with usually two, sometimes three kernels in a pod, bright and clean; color of kernel, light brown; pods adhere well to the plant upon digging. The crop matures in from 165 to 185 days, and yields about 12 cavans of shelled nuts per hectare. Formerly grown at the Lamao Experiment Station, Lamao, Bataan.

P. I. No. 11446: Valencia.—Introduced from Oneco, Florida, U. S. A., on February 25, 1933. Grown for the first time at the former Alabang Rice Experiment Station, Alabang, Rizal. A very promising variety from Spain; a desirable sort for the manufacture of peanut butter; also for blanched and salted peanuts. A heavy yielder, and it matures in from 165 to 185 days after date of planting. Yields about 17 cavans of shelled nuts per hectare. Being grown at the Maligaya Rice Experiment Station, Muñoz, Nueva Ecija.

P. I. No. 11447: Georgia Red.—Introduced from Oneco, Florida, U. S. A., on March 24, 1933. Grown for the first time at the Alabang Rice Experiment Station. This variety is of the bunchy type. The pods are creamy white. Longitudinal ridges and rugae, not very distinct. Usually there are two red kernels in a pod. The kernels which are a little larger than those of the Valencia are about 1.8 centimeters in length. The crop matures in from 150 to 165 days from date of planting, and yields about 14 cavans of shelled nuts per hectare.

P. I. No. 11449: Virginia Jumbo.—Introduced from Oneco, Florida, U. S. A., on March 24, 1933. Grown for the first time at the former Alabang Rice Experiment Station, Alabang, Rizal. The pods of this variety are formed along the lateral

stems, and are with blunt-edged longitudinal ridges; rugae, not so distinct. There are usually two reddish brown kernels in a pod. Matures in from 165 to 185 days, and yields about 18 cavans of shelled nuts per hectare. Being grown at the Maligaya Rice Experiment Station, Muñoz, Nueva Ecija, and at the Los Baños Economic Garden, Los Baños, Laguna.

P. I. No. 13776: Spanish.—Introduced from Reduit, Mauritius, on April 17, 1937. Pods, small averaging 3.2 centimeters in length; strong grower; stems, upright; foliage, abundant and heavy; pods, clustered about base of plant; usually two seeds in a pod; color of peas, light brown; pods adhere well to plant upon digging; longitudinal ridges, rather prominent and sharp; rugae, quite marked. The shell is fairly thick. The period of maturity is from 105 to 125 days. This variety usually yields 19 cavans of shelled nuts per hectare and a ton of hay per acre. The kernels of this variety are rich in oil content. Being grown at the Maligaya Rice Experiment Station, Muñoz, Nueva Ecija and at the Los Baños Economic Garden, Los Baños, Laguna.

P. I. No. 13243: Bukalasa.—Introduced from Entebbe, Uganda, Africa on April 14, 1936. Bunchy type, attaining a height of 32 centimeters; length of vine, 43 centimeters. Shape of pods, bent and twisted, 2 to 4 kernels to the pod; length, 3.45 centimeters; color of shell, cream buff, 2.28 millimeters thick. Shape of kernels, flat at one end and pointed at the other; length of kernel, 1.25 cm. and 0.85 centimeter in diameter. Yield, 24.51 cavans of shelled nuts per hectare. Being grown at the Los Baños Economic Garden, Los Baños, Laguna.

MISCELLANEOUS FRUIT CROPS

P. I. No. 7062: Alpay, Euphoria didyma Bo. (SAPINDACEÆ).—Introduced from Calcutta, India, on October 24, 1919 and grown at the Lamao Experiment Station, Lamao, Bataan. This fruit is also found wild in Cavite, Bataan and other provinces in Luzon. A medium-sized tree with fruits as juicy and sweet as those of the litchi, except that they are green and less meaty. The fruit contains a large, black seed. Found wild in many parts of the Philippines both in dry and humid places. It begins to bear fruits in about 5 to 6 years. Fruiting season: March to June.

P. I. No. 5049: Atemoya, Anona sp. (ANONACEÆ).—A small deciduous tree like the ates. The fruit is sweet and juicy. It

is better in quality and less seedy than the ates. It is a hybrid between the cherimoya and the ates. Introduced into the Islands from the United States, in 1914. Grown at the Lamao Experiment Station, Lamao, Bataan. Thrives best in humid districts about 100 meters above sea level. It begins to bear fruits at the age of three to four years. Fruiting season: April to November.

P. I. No. 1640: Biriba, Rollinia orthopetala A. DC. (ANONACEÆ).—A small to medium sized, semi-deciduous tree. The fruit is heart-shaped with soft projections, and green to yellow in color. The flesh is white, juicy, sweet and of pleasant flavor. A native of Brasil and Guiana. Introduced into the Islands from Mauritius in 1912. Thrives best where there is an even distribution of rainfall. It begins to bear fruits at the age of 3 years. Fruiting season: May to June and October to November.

P. I. No. 3109: Bulala or Laguan, Nephelium mutabile Bl. (SAPINDACEÆ).—Introduced (from Silang, Cavite) at the Lamao Experiment Station, Lamao, Bataan, in 1913. A medium-sized tree with reddish brown, soft, spiny fruits like the rambutan, but less juicy than the latter. Occurs from Northern Luzon to Mindanao and succeeds best in humid districts. It begins to bear fruits in about 6 to 7 years. Fruiting season: May to July.

P. I. No. 8917: Caimito, Chrysophyllum cainito L. (SAPOTACEÆ).—Introduced into the Philippines from Java and Cuba, in 1911. A medium-sized tree with leaves of light golden lower surfaces. The fruit is spherical to oblong in shape, green to brown in color, smooth, with a juicy, sweet and excellent flesh. It is a native of tropical America. It thrives equally well in dry and humid places. It begins to bear fruits at the age of 5 to 6 years. Grown at the Lamao Experiment Station, Lamao, Bataan. Successfully grown especially in the provinces of Cavite, Laguna, and La Union. Fruiting season: January to June. Fruit analysis: moisture, 88.15 per cent; ash, 0.39 per cent; crude fiber, 0.86 per cent; protein, 2.34 per cent; fat, 1.38 per cent; and sugar, 4.4 per cent.

P. I. No. 4097: Cherimoya, Anona cherimolia Mil. (ANONACEÆ).—Introduced into the Philippines from Brisbane, Australia, in 1912. Grown for the first time at the Lamao Experiment Station, Lamao, Bataan. A small tree, 5 to 10 meters high, adapted to high elevations, 750 meters and above. The fruit

is similar to or larger in size than that of the custardapple but it is juicy and deliciously flavored. Successfully grown especially in Bontoc, Mountain Province. Fruiting season: April to December. Fruit analysis: moisture, 66.19 per cent; ash, 0.67 per cent; crude fiber, 4.29 per cent; protein, 1.84 per cent; fat, 0.14 per cent; and sugar, 18.14 per cent.

P. I. No. 3753: Kubili, Cubilia blancoi Bl. (SAPINDACEÆ).—Introduced at the Lamao Experiment Station, Lamao, Bataan, from the Bureau of Forestry, Manila, in 1913. A tree of medium size producing oblong, green and soft spiny fruits; and containing large nuts inside; of excellent flavor when boiled or roasted. Succeeds best where the rainfall is of even distribution. Fruiting season: March to May. Fruit analysis: moisture, 48.24 per cent; ash, 1.47 per cent; crude fiber, 1.21 per cent; protein, 5.2 per cent; fat, 1.92 per cent; starch, 23.13 per cent; and carbohydrates, 18.83 per cent.

P. I. No. 712: Date, Phoenix dactylifera L. (PALMÆ).—Introduced into the Philippines from Syria, in 1911, and grown at the Lamao Experiment Station, Lamao, Bataan. A palm with pinnate leaves and producing the commercial date. It makes a good ornamental. Thrives best where there is very little rainfall and long dry season. The date palm fruited for the first time in Manila in 1930. Analysis of dried date: moisture, 13.80 per cent; ash, 1.2 per cent; protein, 1.9 per cent; fat, 2.5 per cent; and carbohydrates, 70.6 per cent.

P. I. No. 223: Durian, Durio zibethinus L. (BOMBACACEÆ).—Introduced from Singapore, in 1911. A tree 20 meters high, with pointed leaves, silvery beneath. This fruit is quite common in Mindanao and the Sulu Archipelago. Adapted to moist regions at low and medium altitudes. The fruit is large, sometimes exceeding 3 kilos in weight, the whitish, buttery, sweet, aromatic flesh being confined in a hard, bony, and spiny "shell." Fruiting season: January to November. Fruit analysis: moisture, 55.5 per cent; ash, 1.24 per cent; protein, 2.31 per cent; starch, 11.1 per cent; and sugar, 13.55 per cent.

P. I. No. 1675: Galo, Anacolosa luzoniensis M. (OLACACEÆ).—Introduced (from Indang, Cavite) at the Lamao Experiment Station, Lamao, Bataan, in 1912. A tree of medium size about 15 meters high, with alternate simple, pointed leaves; of rather rare occurrence, found from Northern Luzon to Visayas, at low medium elevations. The fruit produced in the axils of the leaves, is a nut of good quality and flavor, about

the size of a filbert. Fruiting season: March to June. Fruit analysis: moisture, 38.5 per cent; ash, 3 per cent; protein, 11.01 per cent; fat, 8.03 per cent; and carbohydrates, 39.46 per cent.

P. I. No. 903: Hevi, Spondias cytherea Son. (ANACARDIACEÆ).—Introduced into the Philippines from Florida, U. S. A., in 1911, and grown for the first time at the Lamao Experiment Station, Lamao, Bataan, where it is successfully grown. A large semi-deciduous tree related to the *siniguelas* with sub-acid fruit as large as a big goose egg. The fruit is orange-yellow when ripe, and has a better keeping quality than the *siniguelas*. The seed is covered with stiff spines to which the flesh is attached. Succeeds well at low altitudes and in dry regions. Begins to bear fruits at the age of 3 to 4 years. Fruiting season: May to December. Fruit analysis: moisture, 85.47 per cent; ash, 0.44 per cent; crude fiber, 0.85 per cent; protein, 0.5 per cent; fat, 0.28 per cent; and sugar, 10.54 per cent.

P. I. No. 2188: Kayam, Inocarpus edulis For. (LEGUMINOSÆ).—A medium sized tree producing a large nut surrounded with fibrous husk, which is hard to separate from the main nut. This nut is prepared and eaten like the chestnut, to which it is similar in taste. Found wild in the Philippines. Propagated in the Lamao Experiment Station, Lamao, Bataan, since 1912. Thrives best both in dry and humid districts. Begins to bear fruits at the age of about 8 to 10 years. Fruiting season: September to November. Fruit analysis: moisture, 48.59 per cent; ash, 1.77 per cent; crude fiber, 0.76 per cent; protein, 5.6 per cent; fat, 1.75 per cent; and carbohydrates, 41.53 per cent.

P. I. No. 5442: Lemasa, Artocarpus champeden Spr. (MORACEÆ).—A tree whose leaves and fruits are very similar to those of the *nangca*. The fruit is of a better quality than the *nangca*, being more fleshy and containing less latex. Introduced from Java, in 1914. Thrives both in dry and humid districts. Begins to bear fruits at the age of 4 to 5 years. Successfully grown in Occidental Negros. Fruiting season: February to September.

P. I. No. 2020: Marang, Artocarpus odoratissima Bo. (MORACEÆ).—Introduced (from Zamboanga) at Lamao Experiment Station, Lamao, Bataan, in 1912. A medium- to large-sized tree with large, sweet, aromatic fruits of good quality. Succeeds best in humid regions with evenly distributed rainfall. Bears fruits at the age of 6 years. Fruiting season: All year round.

P. I. No. 45: Mangosteen, Garcinia mangostana L. (GUTTIFERÆ).—Introduced from Singapore, in 1911. A medium-sized tree with pointed thick, dark green leaves. It is also grown in some parts of Mindanao and Sulu, and adapted to a humid climate, with abundant rains well distributed throughout the year. However, it is found to fruit also in regions with well marked rainfall. The pulp inside the fruit which adheres to the seeds is snow white, sweet and exquisitely flavored. Fruiting season: May to July. Fruit analysis: moisture, 80.2 per cent; ash, 0.23 per cent; protein, 0.5 per cent; and sugar, 16.82 per cent.

P. I. No. 847: Perunkila, Carissa carandas L. (APOCYNACEÆ).—Introduced from Hawaii in 1911 and grown at the Lamao Experiment Station, Lamao, Bataan. A thorny and climbing shrub with small, black and sweet fruit of good flavor about the size of a large duhat but containing much latex. Eaten fresh. It makes a good punch and fairly good pickle. Thrives both in dry and humid regions. Bears fruits at the age of 3 to 4 years. Fruiting season: March to June. Fruit analysis: moisture, 83.23 per cent; ash, 0.66 per cent; crude fiber, 0.62 per cent; protein, 0.39 per cent; fat, 2.57 per cent; starch, trace; carbohydrates, 0.94 per cent; and sugar, 11.58 per cent.

P. I. No. 2730: Berba, Rheedia edulis P. & T. (GUTTIFERÆ).—Introduced from Central America, in 1913. A small tree producing small, brownish or reddish yellow, subacid fruits when fully ripe. The pulp which contains from one to two seeds, is white and recalls the taste of the mangosteen. Thrives well in dry places. Grown at the Lamao Experiment Station, Lamao, Bataan. It begins to bear fruits at the age of 3 years. Fruiting season: April to May and September to December. Analysis: moisture, 84.82 per cent; ash, 0.26 per cent; protein, 1.12 per cent; and sugar, 5.19 per cent.

P. I. No. 2321: Pitanga, Eugenia uniflora L. (MYRTACEÆ).—Introduced from Australia, in 1912. A small shrub bearing reddish, juicy and subacid fruits of the size of a cherry, which when fully ripe are quite delicious. They make a good jelly. Thrives both in dry and humid districts. Bears fruits in about three years. Fruiting season: May to August.

P. I. No. 127: Rambutan, Nephelium lappaceum L. (SAPINDACEÆ).—Introduced from Java, in 1911. Propagated for the first time at the Lamao Experiment Station, Lamao, Bataan. A medium-sized tree with leaves dark green on the upper sur-

face and paler on the nether surface. The fruit is red with soft spines containing a white, juicy flesh of excellent flavor which surrounds a large and oblong seed like that of the cacao. Thrives best in humid regions where the rainfall is well distributed. Bears fruits at the age of about 5 to 6 years. Fruiting season: June to October.

P. I. No. 7080: Tiessa, Lucuma nervosa A. DC. (SAPOTACEÆ).—Introduced from Cuba, in 1915, and grown for the first time at the Lamao Experiment Station, Lamao, Bataan. A small tree producing round to pear-shaped fruit from green to yellow in color and containing 1 to 3 large and brown seeds. The pulp is yellowish, dry, and of a fairly good flavor. Thrives best where the dry season is pronounced. Bears fruits at the age of 3 to 4 years. Successfully grown in the Provinces of Bataan, Cavite and Nueva Ecija. Fruiting season: May to June and October to December. Fruit analysis: moisture, 62.19 per cent; protein, 1.14 per cent; ash, 0.11 per cent; crude fiber, 1.29 per cent; ether extract, 1.18 per cent; and reducing sugar, 9.1 per cent.

P. I. No. 2481: Strawberry var. Wilson, Fragaria chiloensis Dch. (ROSACEÆ).—Introduced from California, U. S. A., in 1913. A low, perennial herb indigenous to South America with carmine-red, juicy, subacid fruits of excellent flavor. Eaten as dessert fruit or preserved. Sucessfully grown in Baguio, Mountain Province. Fruiting season: January to June and December. Fruit analysis: moisture, 90.4 per cent; ash, 0.6 per cent; crude fiber, 1.4 per cent; protein, 1 per cent; fat, 0.6 per cent; and carbohydrates, 6 per cent.

P. I. No. 46: Roselle, Hibiscus sabdariffa L. (MALVACEÆ).—Introduced from the U. S. Department of Agriculture, Washington, D. C., in 1911. An herbaceous spreading annual 1.5 to 3 meters high, with large yellowish handsome flowers, the fleshy calyces of which are used in making preserves, jelly, syrup, and wine; the leaves may also be utilized in the manufacture of jelly, syrup and wines; and also boiled and eaten like spinach. Grows well everywhere from sea level up to an altitude of 900 meters. Fruiting season: November to December. Analysis: moisture, 82.49 per cent; ash, 1.23 per cent; and sugar, 1.06 per cent.

AVOCADO, *Persea Americana* MIL. (LAURACEÆ)

P. I. No. 4852: Cardinal.—A tree of medium size. Fruit bottle-necked; nutritious, rich in fat, appetizing, with nutty flavor;

weight, 300 to 500 grams; yellowish green in color before ripening but purple when ripe, with small yellow dots; can be eaten out of hand; makes an excellent ingredient for making ice cream. Introduced into the Philippines from Florida, U. S. A., in 1914. Grown successfully for the first time at the Lamao Experiment Station, Lamao, Bataan. Thrives best up to 900 meters above sea level. It begins to bear fruits at the age of 5 to 6 years. Yields 200 to 1,000 fruits per tree. Successfully grown especially in the Province of Batangas. Fruiting season: May to September. Fruit analysis: moisture, 88.71 per cent; fat, 3.26 per cent; protein, 0.98 per cent; ash, 0.63 per cent; crude fiber, 1.34 per cent; starch, 2.3 per cent; and reducing sugar, 2.78 per cent.

P. I. No. 3679: Pollock.—Introduced into the Philippines from Miami, Florida, U. S. A., in 1913. The fruit is nutritious, rich in fat, appetizing, with nutty flavor; large, pyriform, weighing 900 to 1,300 grams; color, greenish yellow. Thrives best up to 900 meters above sea level. Grown successfully at the Lamao Experiment Station, Lamao, Bataan. Begins to bear fruits at the age of 5 to 6 years. Yields 200 to 500 fruits per tree. Fruiting season: May to August. Fruit analysis: moisture, 86.55 per cent; fat, 5.26 per cent; carbohydrates, 7.26 per cent; protein, 0.176 per cent; ash, 0.657 per cent; and crude fiber, 1.525 per cent.

P. I. No. 4868–A: Family.—Introduced from the U. S. Department of Agriculture, Washington, D. C., in 1906. A strong growing tree of spreading habit, being an abundant bloomer and moderate cropper. The fruit is nutritious, rich in fat, and is of good flavor and good quality. It is pear shaped; at times oblong. The color is purple, with scarlet streaks. Grown successfully at the Lamao Experiment Station, Lamao, Bataan. Thrives best up to 900 meters above sea level. It begins to bear fruits at the age of 5 to 6 years. Yields from 200 to 400 fruits per tree. Fruiting season: May to August. Fruit analysis: moisture, 85.93 per cent; fat, 6.77 per cent; carbohydrates, 5.64 per cent; protein, 0.95 per cent; and ash, 0.709 per cent.

P. I. No. 4853: Quality.—Introduced from California, U. S. A., in 1907. Fruit obovate to pyriform, weighing 300 to 600 grams; length, 5 to 6 inches; greenish yellow color even when ripe with small maroon dots and a few brown spots. Flesh, whitish yellow; good flavor; good quality; rich in fat. Grown successfully at the Lamao Experiment Station, Lamao, Bataan. Thrives best up to 900 meters above sea level. It begins to bear fruits

at the age of 5 to 6 years. Yields 200 to 300 fruits per tree. Fruiting season: May to July.

P. I. No. 4866: Lyon.—Introduced from the U. S. Department of Agriculture, Washington, D. C., in 1903. Fruited for the first time at the Lamao Experiment Station, Lamao, Bataan. Fruit, oblong pyriform and indistinctly necked in form; weight, 400 to 900 grams; nutritious; of rich flavor and good quality. Thrives best up to 2,500 meters above sea level. It begins to bear fruits at the age of 5 to 6 years. Yields 300 to 600 fruits per tree. Fruiting season: May to August. Fruit analysis: moisture, 85.93 per cent; fat, 6.77 per cent; carbohydrates, 5.641 per cent; protein, 0.95 per cent; and ash, 0.709 per cent.

P. I. No. 4854: Cyrus.—Introduced from Florida, U. S. A., in 1907. Grown successfully for the first time at the Lamao Experiment Station, Lamao, Bataan. Fruit, oblong pyriform, weighing from 350 to 450 grams; greenish yellow or yellowish green even when ripe with yellow dots; rich in flavor; good quality. Thrives best up to 900 meters above sea level. It begins to bear fruits at the age of 5 to 6 years. Yields 200 to 400 fruits per tree. Fruiting season: July to September. Fruit analysis: moisture, 81.76 per cent; fat, 10.12 per cent, carbohydrates, 6.209 per cent; protein, 0.923 per cent; and ash, 0.988 per cent.

P. I. No. 4844: Wester.—Introduced from the U. S. Department of Agriculture, Washington, D. C., in 1913. Grown successfully at the Lamao Experiment Station, Lamao, Bataan. Fruit, roundish oblate, obliquely flattened at the apex, weighing 300 to 600 grams; skin, leathery light green color before ripening but turns to deep purple with maroon russet dots when ripe, adhering closely to the flesh; flesh firm, light yellow color; rich flavor; quality good. Thrives best up to 900 meters above sea level. It begins to bear fruit after 5 to 6 years. Yields, 200 to 400 fruits per tree. Fruiting season: August to October. Fruit analysis: moisture, 84.24 per cent; fat, 7.67 per cent; protein, 1.02 per cent; ash, 0.85 per cent; crude fiber, 1.28 per cent; starch, 2.94 per cent; and reducing sugar, 2 per cent.

P. I. No. 6018: Fuerte.—Introduced from the U. S. Department of Agriculture, Washington, D. C., in 1917. Fruit, pyriform to oblong, weighing from 300 to 400 grams; flesh, rich creamy yellow in color; greenish near the skin; very rich in

flavor; excellent quality. Thrives best at an elevation of 600 meters and above. It begins to bear fruits at the age of 5 to 6 years. Yields 100 to 200 fruits per tree. Fruiting season: August to September. Fruit analysis: moisture, 60.86 per cent; ash, 1.35 per cent; protein, 1.25 per cent; fat, 29.14 per cent; and carbohydrates, 7.4 per cent.

P. I. No. 3678: Baldwin.—Introduced from the U. S. Department of Agriculture, Washington, D. C., in 1913. Grown successfully at the Lamao Experiment Station, Lamao, Bataan. Shape of fruit, approaching oblong; 4 by 5½ inches; flavor, excellent. Thrives best up to 900 meters above sea level. It begins to bear fruits at the age of 5 to 6 years. Yields 100 to 300 fruits per tree. Fruiting season: August to October.

P. I. 1397: Cummins.—Introduced from Honolulu, Hawaii, in 1912. Successfully grown at the Lamao Experiment Station, Lamao, Bataan. Fruit, roundish oblate, weighing from 200 to 400 grams; bright green to yellowish green but turns dark purple when ripe with yellow to russet dots; good flavor, excellent quality. Thrives best up to 900 meters above sea level. It begins to bear fruits at the age of 5 to 6 years. Yields from 100 to 200 fruits per tree. Fruiting season: September to October.

P. I. No. 4850: Commodore.—Introduced from Florida, U. S. A., in 1906. Grown successfully for the first time at the Lamao Experiment Station, Lamao, Bataan. Fruit, from obovate to pyriform, weighing from 160 to 400 grams; surface glossy, yellowish green before ripening and deep purple when ripe with small yellow dots; flesh, light yellow changing to very light yellowish green towards the skin; rich flavor; quality fair. Thrives best up to 900 meters above sea level. It begins to bear fruits at the age of 5 to 6 years. Yields from 100 to 200 fruits per tree. Fruiting season: July to September. Fruit analysis: moisture, 84.35 per cent; fat, 8.13 per cent; protein, 0.64 per cent; ash, 0.81 per cent; crude fiber, 1.21 per cent; starch, 3.07 per cent; and reducing sugar, 1.79 per cent.

P. I. No. 4849: Vega.—Introduced from Cuba, in 1906. Grown successfully for the first time at the Lamao Experiment Station, Lamao, Bataan. Fruit from obovate to broad pyriform, not necked; weight, 300 to 500 grams; surface undulating to rough but glossy, yellowish green before ripening and when ripe, exhibiting small yellowish dots; flesh, creamy color, tinged

with green towards the skin; rich flavor; good quality. Thrives best up to an elevation of about 900 meters above sea level. It begins to bear fruits at the age of 5 to 6 years. Yields 100 to 200 fruits per tree. Fruiting season: August to September.

P. I. No. 4855: Miami.—Introduced from Florida, U. S. A., in August, 1907. Grown successfully at the Lamao Experiment Station, Lamao, Bataan. Matured fruits are dark green in color, turning yellowish green on ripening, weighing 200 to 300 grams; round to slightly oval in shape; good flavor; good quality. Thrives best up to 900 meters above sea level. It begins to bear fruits at the age of 5 to 6 years. Yields 100 to 200 fruits per tree. Fruiting season: July to September. Fruit analysis: moisture, 85.03 per cent; carbohydrates, 3.28 per cent; protein, 0.93 per cent; ash, 0.44 per cent; crude fiber, 1.08 per cent; ether extract, 7.5 per cent; and reducing sugar, 1.74 per cent.

P. I. No. 4872: Douglas.—Introduced from the U. S. Department of Agriculture, Washington, D. C., in 1906. Grown successfully at the Lamao Experiment Station, Lamao, Bataan. Fruit obovate to pyriform and indistinctly necked; weight, 400 to 500 grams; surface smooth and glossy, yellowish green before ripening and deep purple when ripe with yellow dots; flesh, cream yellow in color; of rich flavor and good quality. Thrives best up to 900 meters above sea level. It begins to bear fruits at the age of 5 to 6 years. Yields from 100 to 150 fruits per tree. Fruiting season: August to October. Fruit analysis: moisture, 86.88 per cent; fat, 6.31 per cent; carbohydrates, 5.19 per cent; protein, 0.72 per cent; and ash, 0.9 per cent.

P. I. No. 6026: Puebla.—Introduced from California, U. S. A., in 1910. Form of fruit, obovoid, slightly oblique; weight, 300 to 400 grams; surface, smooth, glossy, deep maroon-purple with numerous reddish dots; flesh, rich cream yellow; buttery in texture, and of rich nutty flavor; quality, very good. Thrives best at an elevation of 600 meters and above. It begins to bear fruits at the age of 5 to 6 years. Yields 150 to 250 fruits per tree. Fruiting season: May to September. Fruit analysis: moisture, 63.32 per cent; ash, 1.56 per cent; protein, 1.8 per cent; fat, 26.68 per cent; and carbohydrates, 6.64 per cent.

P. I. No. 6019: Sharpless.—Introduced from U. S. Department of Agriculture, Washington, D. C., in 1917. Grown successfully at the Lamao Experiment Station, Lamao, Bataan. Fruit slen-

der pyriform; weight, 500 to 700 grams: somewhat rough; purple; of good flavor and good quality. Thrives best up to 2,500 meters above sea level. It begins to bear fruits at the age of 5 to 6 years. Yields 100 to 200 fruits per tree. Fruiting season: June to September. Fruit analysis: moisture, 71.21 per cent; ash, 1.12 per cent; protein, 1.76 per cent; fat, 20.54 per cent; and carbohydrates, 5.43 per cent.

P. I. No. 9118: Trapp.—Introduced from U. S. Department of Agriculture, Washington, D. C., in 1926. Grown successfully at the Lamao Experiment Station, Lamao, Bataan. Form of fruit, roundish oblate, obliquely flattened at the apex; weight, 500 to 700 grams; surface, smooth to undulating or slightly pitted; pale yellow-green, with numerous small to medium-sized, irregular, pale greenish yellow dots; flesh firm, very smooth, rich cream yellow changing to pale green near the skin; flavor, moderately rich, pleasant; quality good. Thrives best up to 900 meters above sea level. It begins to bear fruits at the age of 5 to 6 years. Yields 150 to 300 fruits per tree. Fruiting season: June to October. Fruit analysis: moisture, 78.66 per cent; ash, 0.85 per cent; protein, 1.61 per cent; fat, 9.8 per cent; and carbohydrates, 9.08 per cent.

REFERENCES

ANONYMOUS. A descriptive list of some forage grasses for distribution by the Bureau of Agriculture for trial planting. Phil. Agr. Rev. **18** (1925) 299–301. (Also P. I. Bureau of Agriculture Circular No. 162.)

ANONYMOUS. Records of the Bureau of Plant Industry, Department of Agriculture and Commerce.

ANONYMOUS. Sugar cane variety tests of the Bureau of Agriculture. Phil. Agr. Rev. **20** (1927) 367–74.

ASUNCION, S. and M. MEDINA. Results of the variety tests of sugar cane in the years 1921–1923 at the La Carlota Experiment Station. Phil. Agr. Rev. **18** (1925) 107–23.

CRUZ, A. O. and A. P. WEST. Composition of Philippine peanut oil. Philip. Journ. Sci. **46** (1931) 199–207.

DORYLAND, E. D. Valuable forage crops for the Philippines. Phil. Bur. Agr. Cir. 50.

DORYLAND E. D. and H. C. KINGMAN. The principal forage crops of the Philippines. Phil. Agr. Rev. **10** (1917) 261.

GALANG, F. G. and P. L. PAULINO. A progress report on forage crop investigations at the Lamao Experiment Station, Lamao, Bataan. Phil. Agr. Rev. **22** (1929) 183.

GALANG, F. G. and P. L. PAULINO. A progress report on peanut variety test at the Lamao Experiment Station, Lamao. Bataan. Phil. Agr. Rev. **18** (1925) 261–72.

LABRADOR, A. and F. D. MARAMBA. Results of a five-year sugar cane variety test at La Carlota Experiment Station, Occidental Negros. Phil. Jour. Agr. 2 (1931) 162–77.

LANUZA, E. A. and M. MANAS y CRUZ. The Alunan cane in the sugar industry of Negros. Phil. Jour. Agr. 8 (1937) 311–25, pl. 1–5, fig. 1.

LEE, H. A. A summation of the comparative yields from cane variety tests conducted by the Philippine Sugar Association. Sugar News 9 (1928) 163–169.

MANAS y CRUZ, M., V. R. OLAN, and E. K. MORADA. 1933 Annual report of the committee on avocado, caimito and lanzon (unpublished).

PADOLINA, FELIPE. Avocado varieties at the Lamao Experiment Station. Philippine Farm Journal 3 (1930) No. 2, 16–17.

UNITE, J. O. and F. D. MARAMBA. Sugar cane varieties under Negros conditions. Bureau of Plant Industry Contributions to Knowledge of Philippine Agriculture. 1932. Manila: Bureau of Printing. Pp. 11–14.

VILLYAR, P. A. The introduction of avocado. Bureau of Plant Industry Contributions to Knowledge of Philippine Agriculture. 1931. Manila: Bureau of Printing. Pp. 58–59.

ILLUSTRATIONS

PLATE 1

A field of P.O.J. 2878 (P. I. No. 4910).

PLATE 2

Badila cane (P. I. No. 8743).

PLATE 3

A field of Napier grass, *Pennisetum purpureum* Schum. (P. I. No. 5488). Lamao Experiment Station, Limay, Bataan.

PLATE 4

Guinea grass, *Panicum maximum* Jacq. (P. I. No. 1819) at the Singalong Experiment Station, Manila.

PLATE 5

A field of Guatemala grass, *Tripsacum laxum* Nees. (P. I. No. 6933) at the Lipa Demonstration Station, Lipa, Batangas.

PLATE 6

Peanut varieties. From left to right: San Jose No. 1 (P. I. No. 7980); Bukalasa (P. I. No. 13243); and Tennessee Red (P. I. No. 13769).

PLATE 7

Two plots of peanuts: Virginia Jumbo (P. I. No. 11449), left, and Spanish (P. I. No. 13766), right.

PLATE 8

A bearing caimito, *Chrysophyllum cainito* L. (P. I. No. 8917) at the Los Baños Economic Garden, Los Baños, Laguna.

PLATE 9

A bearing cherimoya tree, *Anona cherimolia* Mil. (P. I. No. 4097) at the Central Experiment Station, Manila.

PLATE 10

Roselle plants, *Hibiscus sabdariffa* L. (P. I. No. 46) in bloom.

PLATE 11

A budded Cardinal avocado (P. I. No. 4852) at the Lamao Horticultural (formerly Lamao Experiment) Station, Limay, Bataan.

PLATE 1.

PLATE 2.

PLATE 1.

PLATE 4.

PLATE 1.

PLATE 6

PLATE 7.

PLATE 8

PLATE 9.

PLATE 10.

PLATE 11.

RICE CADANG-CADANG IN ALBAY PROVINCE: II. FERTILIZER TREATMENTS

By Julian A. Agati and Fernando de Peralta

Of the Bureau of Plant Industry

Just after the pot fertilizer experiments were completed and plans were being made to extend the results in the field, the Provincial Board of Albay appropriated the sum of ₱500 to finance field studies on the malady. Since the Bureau was called upon to undertake the project, a plan of experiments based on the results obtained from the previous pot culture studies was immediately prepared.

In the previous pot culture experiments,(1) and (2) it was found that rice *cadang-cadang* was largely the result of plant food deficiency in the soil, particularly nitrogen. Following this significant lead, treatments using commercial fertilizers were conducted in previously *cadang-cadang* infested soils in Albay Province.

The field experiments were started in April, 1938 and ended in September, 1938. The places selected for the projects were Kinale, Polangui; Mayao, Oas; and Ologon, Libon,[1] all of Albay Province. These towns were believed to be ideal for the experiments because they are known to be previously affected by rice *cadang-cadang*. Moreover, the soil samples used for analyses and for pot culture studies were obtained from the above-mentioned places.

The aims in undertaking the field experiments were: (1) to conduct a field test of the fertilizers found in the laboratory to reduce the effects of *cadang-cadang* and (2) to determine, under field conditions, the most desirable combination of the suitable fertilizers and the rate at which they may be applied per hectare with a reasonable profit.

[1] Two days after the application of fertilizers there was a heavy downpour, inundating the entire field. Before and during the blooming period heavy rains and strong winds again occurred. These conditions affected adversely the experiments so that their inclusion here is not advisable.

MATERIALS AND METHODS

Preparation of the fields.—The land was first irrigated to soften it before plowing. The clods were broken and the weeds removed by thorough harrowing. The entire field was flooded, keeping the weeds submerged until they rotted, after which time the water was drained off so that the land could be harrowed and leveled again preparatory to planting.

The dikes, about 25 cm. high and 25 cm. wide, were made next. They were constructed in such a way that one plot could be irrigated independently of the others, thus avoiding mixing the fertilizers that were applied later.

Each experimental field was divided by dikes into equal plots of almost 120 square meters each. These individual plots were further subdivided into smaller unit plots by smaller dikes, each having an area of approximately 40 square meters. In Kinale, Polangui, there were 60 unit plots, 45 of which were treated and 15 were checks. The same number of unit plots was employed in Mayao, Oas; 45 were fertilized and the rest used as controls.

Transplanting.—The seedlings used were of the Baranay variety, which is planted there extensively. The seedlings which were at least 45 days old were furnished by our coöperators. Three seedlings were planted to a hill in order to give allowance for deaths. The distance between hills was 25 cm. each way. The Kinale experiment was started on May 5, 1938, and that at Oas, on June 7, 1938.

Application of fertilizers.—The fertilizers were applied about one month after transplanting. Before the applications were made, the individual plots were drained of their water, keeping them just sufficiently moist so as to insure a uniform effect of the fertilizers. The fertilizers, especially the combined ones, were ground and mixed thoroughly before they were broadcasted evenly on the plots. After ten days, or as soon as the fertilizers were incorporated in the soil, the plots were again irrigated taking care that no overflowing or mixing of the fertilizers from different paddies occurred. The irrigation was maintained up to blooming period, but as soon as the grains began to form the water was gradually drained from the plots until there was practically no water at harvest time.

The commercial fertilizers used were sulphate of ammonia, double superphosphate of lime and sulphate of potash. The

combinations or treatments used were N, NP, NK, and NPK. These treatments or combinations were applied at the following rates: The minimum rate of fertilizers applied was 150 kilos per hectare; the medium rate, 200 kilos per hectare; and the maximum rate, 250 kilos per hectare.

For the sake of brevity in the discussion, the treated plots were designated as A_1 to A_3; B_1 to B_3; C_1 to C_3 and the controls were represented by D. The symbols, A_1, A_2 and A_3 stand for the nitrogen (N) treatment. A_1 represents the minimum rate of application, A_2, the medium rate of application, and A_3 the maximum rate of application. The letters B were used to designate the sulphate of ammonia and double superphosphate of lime (NP) applications in three different amounts as already mentioned above. The letters C represent the complete fertilizer treatments (NPK) in different amounts and the letter D stands for the control.

In order to determine the effect or value of adding fertilizers in controlling *cadang-cadang,* the following observations were made: (1) the general stand of the plants; (2) the occurrence of *cadang-cadang;* (3) the average height of plants; (4) the average number of tillers; (5) the average weight of clean palay. and (6) the computed yield per hectare in kilos and cavans.

The height of the plants and the number of tillers were observed and recorded monthly from the time the plants were about one month old to the time of maturity and harvest. It was necessary to carry monthly observations in order to determine at what stage the rice plants succumbed to *cadang-cadang.* There were measured 20 plants from each treatment, which was replicated five times. In measuring the plants, bamboo stakes were driven at the base of each plant to be measured in order to avoid confusion in the succeeding measurements and thus minimize errors in our records. Each plant was measured from its base to the highest leaf tip. For obvious reasons the yields were not computed on the hectare basis but were given as the actual average production per plant per treatment. The yields from the individual plots, however, were used in computing the yields on a hectare basis, and thus evaluate each treatment in its effect in minimizing the damage by *cadang-cadang.*

RESULTS

The results of the experiments are shown in the following tables:

TABLE 1.—*Comparative effects of fertilizers on the stand, growth and yield per plant in Kinale, Polangui where cadang-cadang was previously rampant*

Plot number	Treatment and rate of application per hectare (kilos)	Average height of plants (cm.)	Average number of tillers	Average yield per plant based on 100 plants (gms.)	Probable error of difference	Treated and control compared	Observations on the stand and growth of plants
A 1	Ammonium sulphate 150	150	12.0	37.32±2.3030	14.54±2.4212	Significant	Fairly good stand, no *cadang-cadang*.
A 2	Ammonium sulphate 200	152.7	13.0	36.32±1.7046	13.54±1.8614	do	Do.
A 3	Ammonium sulphate 250	149.0	13.5	34.88±3.2219	12.10±3.3075	do	Good stand, no *cadang-cadang*.
B 1	Ammonium sulphate 150 Double superphosphate 150	141.6	11.8	31.92±2.0756	9.14±2.2062	do	Fairly good stand, no *cadang-cadang*.
B 2	Ammonium sulphate 200 Double superphosphate 200	148.8	12.4	32.26±2.2074	9.48±2.3306	do	Do.
B 3	Ammonium sulphate 250 Double superphosphate 250	151.9	14.0	34. 4±2.7991	11.62±2.8973	do	Good stand, no *cadang-cadang*.
C 1	Ammonium sulphate 150 Double superphosphate 150 Potassium sulphate 150	147.9	13.6	35.78±2.5354	13.0 ±2.6434	do	Do.
C 2	Ammonium sulphate 200 Double superphosphate 200 Potassium sulphate 200	151.3	12.25	31.92±1.6004	9.14±1.7665	do	Fairly good stand, no *cadang-cadang*.
C 3	Ammonium sulphate 250 Double superphosphate 250 Potassium sulphate 250	178.3	14.5	36. 2±2.8880	13.42±2.9832	do	Do.
D (Control)	No fertilizer	117.5	7.5	22.78±0.7480			The plants were yellow and somewhat stunted, *cadang-cadang* present.

TABLE 2.—*Comparative effects of fertilizers on the yields of the experimental plots in Kinale, Polangui where cadang-cadang was previously rampant*

Plot number	Treatment and rate of application per hectare (kilos)	Actual average yield per plot (kilos)	Computed yield per hectare		Probable error of difference	Treated and control compared	Observations on the stand and growth of plants
			Kilos	Cavans			
A 1	Ammonium sulphate 150	10.1	2,525.0	57.91±2.4619	13.19±2.540	Significant.	*Cadang-cadang* symptom absent.
A 2	Ammonium sulphate 200	10.2	2,550.0	58.48±3.8783	13.76±3.9284	do.	Do.
A 3	Ammonium sulphate 250	11.2	2,750.0	64.21±3.1210	19.49±3.2143	do.	Do.
B 1	Ammonium sulphate 150 Double superphosphate 150	11.0	2,750.0	63.07±3.8875	18.35±3 9374	do.	Do.
B 2	Ammonium sulphate 200 Double superphosphate 200	11.3	2,825.0	64.78±1.2003	20.06±1.3534	do.	Do.
B 3	Ammonium sulphate 250 Double superphosphate 250	12.1	3,025.0	69.33±5.6504	24.66±5.6849	do.	Do.
C 1	Ammonium sulphate 150 Double superphosphate 150 Potassium sulphate 150	10.4	2,550 0	59.63±1.0175	14.91±1.1943	do.	Do.
C 2	Ammonium sulphate 200 Double superphosphate 200 Potassium sulphate 200	11.9	2,975 0	68.23±3.6205	23.41±3.6741	do.	Do.
C 3	Ammonium sulphate 250 Double superphosphate 250 Potassium sulphate 250	14.3	3,575.0	81.99±1.4262	37.27±1.5572	do.	Do.
D (Control)	No fertilizer	7.8	1,950 0	44.72±0.6254			*Cadang-cadang* symptom present.

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TABLE 3.—*Comparative effects of fertilizers on the stand, growth and yields per plant in Mayao, Oas, where cadang-cadang was previously rampant*

Plot number	Treatment and rate of application per hectare (kilos)	Average height of plants (cm.)	Average number of tillers	Average yield per plant based on 100 plants (gms.)	Probable error of difference	Treated and control compared	Observations on the stand and growth of plants
A 1	Ammonium sulphate 150	140.0	12 0	39.4 ±2.3239	17.32±2.6778	Significant	Good stand, no *cadang-cadang*.
A 2	Ammonium sulphate 200	127.2	12.1	39.8 ±1.4593	17.72±1.9748	do	Do.
A 3	Ammonium sulphate 250	127.4	12.0	36.28±3.1946	14.2 ±3.4606	do	Fairly good stand, no *cadang-cadang*.
B 1	Ammonium sulphate 150 Double superphosphate 150	109.0	10.0	34.12±2.0326	12.04±2.4293	do	Do.
B 2	Ammonium sulphate 200 Double superphosphate 200	109.4	12.0	34.36±2.1154	12.28±2.4990	do	Good stand, no *cadang-cadang*.
B 3	Ammonium sulphate 250 Double superphosphate 250	116.0	9.0	36.72±2.8022	14.64±3.1020	do	Do.
C 1	Ammonium sulphate 150 Double superphosphate 150 Potassium sulphate 150	115.5	9.7	39.02±2.3331	16.94±2.6858	do	Do.
C 2	Ammonium sulphate 200 Double superphosphate 200 Potassium sulphate 200	112.2	12.0	34.38±1.5850	12.30±2.0694	do	Fairly good stand, no *cadang-cadang*.
C 3	Ammonium sulphate 250 Double superphosphate 250 Potassium sulphate 250	109.7	11.8	39.64±2.7769	17.56±3.2607	do	Do.
D (Control)	No fertilizers	87.5	7.5	22.08±1.3306			The plants were yellow and stunted; *cadang-cadang* present.

TABLE 4.—*Comparative effects of fertilizers on the yields of the experimental plots in Mayao, Oas where cadang-cadang was previously rampant*

Plot number	Treatment and rate of application per hectare (kilos)	Actual average yield per plot (kilos)	Computed yield per hectare		Probable error of difference	Treated and control compared	Observations on the stand and growth of plants
			Kilos	Cavans			
A 1	Ammonium sulphate 150	9.66	2,415.0	55.37±1.0869	20.39±1.6721	Significant	*Cadang-cadang* symptom absent.
A 2	Ammonium sulphate 200	10.65	2,662.50	61.05±1.0945	26.07±1.6899	do	Do.
A 3	Ammonium sulphate 250	8.4	2,100.00	48 14±2.6888	13.16±2.9812	do	Do.
B 1	Ammonium sulphate 150 Double superphosphate 150	8.65	2,162.50	58 8 ±1.1649	23 82±1.7363	do	Do.
B 2	Ammonium sulphate 200 Double superphosphate 200	8.87	2,217.50	50.78±1.8855	15.80±2.2832	do	Do.
B 3	Ammonium sulphate 250 Double superphosphate 250	9.16	2,290.00	51.35±1.7046	16.37±2.1362	do	Do.
C 1	Ammonium sulphate 150 Double superphosphate 150 Potassium sulphate 150	7.6	1,900.0	43 56±1.5155	8.58±1.9855	do	Do.
C 2	Ammonium sulphate 200 Double superphosphate 200 Potassium sulphate 200	8.6	2,150.0	49.29±2.4465	14.31±2.7646	do	Do.
C 3	Ammonium sulphate 250 Double superphosphate 250 Potassium sulphate 250	7.6	1,913.0	43.56±1.5115	8.58±1.9655	do	Do.
D (Control)	No fertilizers	6.1	1,525.0	34.98±1.0876			*Cadang-cadang* symptom present.

DISCUSSION OF RESULTS

(*a*) *The Kinale experiments.*—At the start, both fertilized and control plants were practically of the same stand. However, two weeks after the application of fertilizers, the treated plants showed a conspicuous headway, while the controls were generally of uneven stand and of poor growth. A month or so later, the plants treated with nitrogen of various amounts showed dark, broad, green leaves in contrast with those of the controls, which were generally stunted, having thin stalks, few tillers and narrow, pale and dry leaves.

Referring to table 1, and considering the nitrogen treatment first, it is apparent that the heights of the plants, irrespective of the amount applied, did not vary very much. All those under the different treatments came well within the 150-centimeter mark. The same may also be said of the number of tillers and average yield per plant based on 100 individuals. The variation was not much.

Taking up the double superphosphate-ammonium sulphate treatment, the heights of the plants varied proportionately with the amount of fertilizers used. The plants, however, were generally smaller than those treated with nitrogen alone. The number of tillers and average yield per plant were irregular but both varied according to the proportions of the fertilizers used.

The plants treated with complete fertilizers attained certain heights that varied according to the amounts of fertilizers applied. Although the tillering habits were as good as those in the other treatments, the plants did not follow the variations in the amounts of fertilizers applied. It is interesting to note, however, that the yields were no better than those of the other treatments. On the contrary, the nitrogen treatment showed even a more decided advantage in yield.

The controls reached just a little over a meter high, produced only one-half as many tillers as those of the treated, and gave considerably lower yields.

In table 2, the computed yields per hectare in cavans of those treated with different fertilizers were generally higher than those of the controls.

Considering the results obtained from the three different treatments and picking at random only the good yields so that they could be arranged in consecutive order, it is apparent that the maximum application of nitrogen gave 64 cavans to the

hectare, the maximum application with double superphosphate-ammonium sulphate, 69 cavans, while that of the complete fertilizer mixture gave 81 cavans. While the value of this result is self-evident, it does not seem safe to say that this will always hold true, and that therefore the other treatments are to be left out of consideration. For example, the results from using a maximum amount of nitrogen which are more or less equal to those obtained from using a medium amount of double superphosphate-ammonium sulphate mixture, are even better than the results derived with the use of the minimum amount of complete fertilizer mixture. Likewise, the use of the maximum amount of phosphate-ammonium sulphate was even more successful than that of medium complete mixture. Although the maximum phosphate-ammonium sulphate mixture and both the medium and maximum complete fertilizer mixtures, respectively, were apparently good, nitrogen treatment may still be preferred if production cost is considered.

(*b*) *Mayao experiments.*—Like the results obtained in Kinale, the most noticeable characteristic of the Mayao experiments, is the great contrast between the treated plants and the controls. While the fertilized plants produced conspicuously broad, green leaves after a month or so of growth, the controls did not only exhibit uneven stand and stunted growth but they also presented a somewhat burned appearance from a distance. This showed unmistakably the effects of *cadang-cadang*. At harvest time, the control plants did not only produce slender stalks and few tillers but also gave considerably much smaller yields than the treated.

Referring to table 3 and taking into account the heights of the plants treated with different amounts of ammonium sulphate, it is surprising to note that the minimum application of nitrogen produced the tallest plants. Those with medium and maximum applications, besides being smaller than those treated with minimum amount, were uniformly the same, and so with the number of tillers in both cases. These differences in the vegetative growth did not materially vary the yields, which were practically the same in all cases.

In the double superphosphate-ammonium sulphate mixture, the tallest plants were found among those treated with maximum applications of the mixture, although they produced comparatively few tillers. These slight differences did not vary the yields, which remained uniformly the same.

The plants treated with a complete mixture were practically uniform in height, irrespective of the amounts of the mixture used. The tillers, however, were more predominant with the use of more of the fertilizers. These slight differences in the stand of the plants were not sufficient to vary the yields among the different treatments.

The controls were comparatively small and were even below one meter high. The tillers were few and the plants as a whole yielded very little, showing the effects of *cadang-cadang*.

Considering the yields in cavans as given in table 4, the effects of the ammonium sulphate application were conspicuous. It is also apparent that the harvests from the phosphate-nitrogen treatment, although generally less than those of the nitrogen applications, were even better than those obtained from the use of a complete fertilizer mixture regardless of the amounts applied. Apparently this implies two things: one is that nitrogen may still prove to be the most economical to use under Mayao conditions, and another is that nitrogen helps a great deal in minimizing the effects of *cadang-cadang;* hence it augments the yield. Mayao has been known to be more severely infested previously with *cadang-cadang* than the lot in Kinale. It seems thus evident that, although the results of the experiments as indicated by the use of fertilizers that the *cadang-cadang* malady is linked with a deficiency in or insolubility of soil nutrients, nitrogen and phosphoric acid seem to be most deficient in amount as far as Mayao is concerned. This does not seem so in the case of Kinale, yet the limiting effect of nitrogen can not be ignored in the latter place.

THE ECONOMICS OF THE EXPERIMENTS

In estimating the increase in yields due to the treatments, the cost of fertilizers and application was considered. Thus, basing from the prices of the fertilizers obtained from Menzi and Co.[1] and the current selling price of clean palay at ₱2.50 per

[1] The prices of the fertilizers used were as follows:

1 ton, sulphate of ammonia..... ₱ 92.00, or ₱ 4.85 per sack of 50 kg.
1 ton, double superphosphate of lime ..... ₱125.00, or ₱13.00 per sack of 100 kg.
1 ton, sulphate of potash..... ₱120.00, or ₱12.50 per sack of 100 kg.

cavan, and the expenses involved, the profit gained or the losses sustained in the experiment may be tabulated as follows:

TABLE 5.—*Summary results of the experiments in Kinale, Polangui.*

Treatments		Increase in yield over control per hectare	Value of increased yield per hectare	Cost of fertilizers and application	Gain (+) or loss (—) per hectare
Fertilizers used	Rate per hectare				
	Kilogram	*Cavans*	*Pesos*	*Pesos*	*Pesos*
Ammonium sulphate	150	13.19	32.98	14.80	+18.18
Do	200	13.76	34.40	19.40	+15.00
Do	250	19.49	48.72	24.00	+24.72
Do	150	18.35	45.87	34.05	+11.82
Double superphosphate	150				
Ammonium sulphate	200	20.06	50.15	44.90	+ 5.25
Double superphosphate	200				
Ammonium sulphate	250	24.66	61.65	55.75	+ 5.90
Double superphosphate	250				
Ammonium sulphate	150	14.91	37.27	46.55	— 9.28
Double superphosphate	150				
Potassium sulphate	150				
Ammonium sulphate	200	23.41	58.52	63.40	— 4.88
Double superphosphate	200				
Potassium sulphate	200				
Ammonium sulphate	250	37.27	93.17	80.25	+12.92
Double superphosphate	250				
Potassium sulphate	250				

TABLE 6.—*Summary results of the experiments in Mayao, Oas.*

Treatments		Increase in yield over control per hectare	Value of increased yield per hectare	Cost of fertilizers and application	Gain (+) or loss (—) per hectare
Fertilizers used	Rate per hectare				
	Kilogram	*Cavans*	*Pesos*	*Pesos*	*Pesos*
Ammonium sulphate	150	20.39	50.97	14.80	+36.17
Do	200	26.07	65.17	19.40	+45.77
Do	250	13.16	32.90	24.00	+ 8.90
Do	150	23.82	59.55	34.05	+25.50
Double superphosphate	150				
Ammonium sulphate	200	15.80	39.50	44.90	— 5.40
Double superphosphate	200				
Ammonium sulphate	250	16.37	40.92	55.75	—14.83
Double superphosphate	250				
Ammonium sulphate	150	8.58	21.45	46.55	—25.10
Double superphosphate	150				
Potassium sulphate	150				
Ammonium sulphate	200	14.31	35.77	63.40	—27.63
Double superphosphate	200				
Potassium sulphate	200				
Ammonium sulphate	250	8.58	21.45	80.25	—58.80
Double superphosphate	250				
Potassium sulphate	250				

Considering the nitrogen treatments in table 5, the 250-kg. application appears to be most profitable, the 200-kg. rate comparatively poor, and the 150-kg. treatment fairly good.

Of the NP combinations, the use of 150 kg. per hectare is fairly profitable, whereas both the 200-kg. and 250-kg. treatments yielded almost equal profits.

The complete mixture (NPK) is profitable when applied at the rate of 250 kg. per hectare.

It is thus apparent that, with the Kinale experiment, only two cases out of the 9 different treatments did not show profits, yet the best results, as far as monetary returns are concerned, were obtained with the maximum application of N, the minimum application of NP, and the maximum application of NPK. This indicates that nitrogen alone, or in combination with P_2O_5, when applied to *cadang-cadang* soil, yielded reasonable profits.

As regards the Mayao experiments, the two nitrogen treatments yielded substantial gains. With the nitrogen-phosphoric acid treatment, only the minimum rate showed a profitable return while neither of the other two rates showed any gain. The complete fertilizer treatments were all considerably below cost.

From the foregoing discussions, it is evident that although all the treated fields outyielded their corresponding controls as previously seen in the discussion of yields, all the treatments, however, did not prove to be profitable when the cost of fertilizers and the cost of application were taken into account. This was more striking in the case of the Mayao field. The results of these experiments present some facts worthy of consideration. It would seem that although the fertilizers were required by the plants, there is a certain limit beyond which their application will no longer be profitable. It would seem also that the kind of combinations and amounts of fertilizers used determine largely the results of the experiment. These two factors apparently were at work in our experiments.

SUMMARY

1. The present paper gives the results of experiments in the field using different amounts and mixtures of commercial fertilizers in an effort to minimize the infestation of *cadang-cadang*.

2. The experiments were conducted in two different places where *cadang-cadang* was known to have gotten a foothold during the last two planting seasons.

3. As shown by the controls, *cadang-cadang* appears a month or so after transplanting; the plants are stunted and they present an uneven stand, and the leaves are pale green to yellow.

4. The results of the experiments point out the possibility of making *cadang-cadang* soils more productive by the use of such commercial fertilizers as sulphate of ammonia, double superphosphate of lime and sulphate of potash.

5. When the costs of fertilizers and application are considered, the use of sulphate of ammonia alone, applied at the rate of 150–250 kg. per hectare, proved as profitable as with the use of a mixture of double superphosphate and sulphate of ammonia or a mixture of double superphosphate, sulphate of ammonia and sulphate of potash applied at the same rate per hectare.

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LITERATURE CITED

1. Agati, J. A. Preliminary studies on the so-called rice *cadang-cadang* in the Bicol provinces. (Unpublished.)
2. Peralta, F. de and Julian A. Agati. Rice *cadang-cadang* in Albay Province: I. Its probable cause. Phil. Jour. Agr. 10 (1939) 153–169, pls. 1–7.

STUDY ON THE VITALITY OF OLD AND NEW SEEDS OF MUNGO (*PHASEOLUS AUREUS* ROXB).[1]

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ONE PLATE

That the seeds of many economic plants can maintain their viability for a number of years under proper storage conditions have been shown by a number of investigators, (2), (3), (4), (5) and (6). This leads to some speculation at least as to the value of old but viable seeds for planting purposes. As a matter of fact, the writer (3), in the discussion of the results of his studies on the longevity of some farm crop seeds, pointed out the possibility for "plant breeders who are testing a large number of varieties and strains under limited means. . . . to store part of their materials to be tested gradually in later years." This possibility was pointed out on the assumption that old and new seeds of the same variety or strain with good viability have practically the same yielding power.

To obtain some information on the behavior of old seeds as planting materials, the writer undertook a study on the vitality of old and new seeds of mungo, *Phaseolus aureus* Roxb. It may also be pointed out that any information on the vitality of old seeds expressed in terms of the vigor and yielding power of the resulting plants would be very useful in the disposal of viable old seeds by farmers and seed houses.

The study which was undertaken at the Central Experiment Station, Bureau of Plant Industry, Manila, was started in February, 1935, and the last culture was harvested in September, 1937.

MATERIALS AND METHODS

The mungo seeds used in the four cultures made in this study were taken from the materials used first by Vibar and the writer (4), and later by the writer (3) in their study of the longevity of some farm crop seeds. The variety was the Native Yellow

[1] Read at the Fifth Philippine Science Convention (Division of Biology), February 21–26, 1939.

with dull seed coat. The seeds were 11 years and 4 months old in storage when the first culture was started.[1] The new seed, which in this case was used as check, was taken from plantings of the old seed previously made. These were done so as to be sure that the old and new seeds used in the study were of the same variety or strain; and in such an arrangement that the newly produced seeds were one month old when the cultures were made.

Four different sets of cultures were made. The first culture was made in ordinary garden plots while the other three were planted in earthen pots, which had an inside top diameter of 23 centimeters and an inside bottom diameter of 20 centimeters and a depth of 20 centimeters.

In the first culture, the seeds were first germinated in a seedbox. As the seedlings began to produce their true leaves, they were picked up carefully from the seedbox with a trowel with precaution to include practically all the roots. Each set of seeds was represented by 100 good seedlings and these were transplanted singly at 25 centimeters apart in rows spaced 30 centimeters apart. At maturity, however, each kind of seed was represented only by 56 or more plants due to some mortality in the course of their development. In the three sets of pot cultures, the seeds were directly planted in the pots, each kind of seed having been represented by 30 pots. Six to eight seeds were sown in each pot, but later the seedlings were thinned to three per pot when they had about two to three true leaves. Each set of culture was treated practically the same with respect to cultivation, spraying, weeding, and watering. At maturity, the plants were harvested, and data on the number of pods produced, weight of dry pods, weight of straw, and weight of seeds, per plant were taken.

EXPERIMENTS AND RESULTS

The results of this study are summarized in tables 1 to 4. Among other things, they show the average number of pods produced per plant, the weight of the straw and pods, and the weight of the grains or seeds. Table 1 gives a summary of the first culture, which was a rainy season culture. The stand of the plants was good. In table 2 are presented the summary

[1] The seeds were stored in bottles which were sealed with paraffin, thus making them air tight. Before storing, however, they were first dried thoroughly in the sun.

results of the second culture. This was a dry season culture; the stand of the plants was good but only few pods were produced, perhaps because of spraying in an attempt to check the growth of aphids during their flowering stage.

TABLE 1.—*Relative yields of one-month and 11-year, 4-month-old mungo seeds (first culture)*

Characters studied	New seed [a]	Old seed [b]	Difference	Significance of difference
Weight of straw [c] in gram per plant	11.36±0.55	21.86±2.03	10.50±2.33	Significant.
No. of pods per plant	9.00±0.74	17.80±1.56	8.80±1.73	Do.
Weight of pods in gram per plant	5.36±0.45	10.52±0.92	5.16±1.02	Do.
Weight of grain in gram per plant	3.23±0.31	6.83±0.78	3.60±0.84	Do.

[a] One-month old seeds after harvest.
[b] Eleven-year and 4-month old seeds in storage.
[c] Weight was taken just after harvesting the pods.

TABLE 2.—*Relative yields of new and old mungo seeds (second culture)*

Characters studied	New seed [a]	Old seed [b]	Difference	Significance of difference
Weight of straw [c] in gram per plant	1.15±0.04	1.26±0.04	0.11±0.056	Insignificant.
Weight of pods in gram per plant	1.82±0.07	2.64±0.11	0.82±0.130	Significant.
Weight of grain in gram per plant	1.33±0.05	1.73±0.06	0.40±0.070	Do.

[a] One-month old seeds after harvest.
[b] Twelve-year and 9-month old seeds in storage.
[c] The plants were already defoliated when they were cut for straw yield.

Table 3 presents the summary of the results of the third culture, which was a late dry season crop. The stand of the plants was good and so was the yield. Table 4 summarizes the results of the last culture, which was a rainy season crop. The stand of the plants was very good. These were later affected by a mild typhoon during the blooming stage.

TABLE 3.—*Relative yields of new and old mungo seeds (third culture)*

Characters studied	New seed [a]	Old seed [b]	Difference	Significance of difference
Weight of roots in gram per plant	3.20±0.14	3.65±0.19	0.45±0.24	Insignificant.
Weight of straw in gram per plant	16.00±0.44	15.20±0.52	0.80±0.68	Do.
Number of pods per plant	11.06±0.50	17.39±0.59	6.33±0.76	Significant.
Weight of pods in gram per plant	6.98±0.34	11.18±0.42	4.20±0.54	Do.
Weight of grain in gram per plant	5.33±0.27	8.38±0.29	3.06±0.39	Do.

[a] One-month old seeds after harvest.
[b] 13-year old seeds in storage.

TABLE 4.—*Relative yields of new and old seeds of mungo (fourth culture)*

Characters studied	New seed [a]	Old seed [b]	Difference	Significance of difference
Height of plant in centimeters	24.70±0.51	27.26±0.52	2.56±0.73	Significant.
Weight of straw in gram per plant	2.20±0.12	2.68±0.14	0.48±0.18	Slightly significant.
Weight of pods in gram per plant	2.58±0.16	2.51±0.14	0.07±0.21	Insignificant.
Weight of grain in gram per plant	1.64±0.13	1.58±0.11	0.06±0.17	Do.

[a] One-month old seeds after harvest.
[b] Thirteen-year and 5-month old seeds in storage.

DISCUSSION OF RESULTS

The vitality of a seed is not only measured by its ability to germinate but also very largely by its ability to produce a vigorous seedling that matures into a normal plant. In this study, the criteria that were used in the determination of the relative vitality of the new and old seeds of mungo were (1) the weight of straw, (2) the weight of pods, and (3) the weight of beans produced per plant.

Weight of straw.—From the appearance and general stand of the plants, the difference was not marked except in the first culture where the plants from the old seeds appeared to be more stocky and had more branches than those from the fresh seeds. In the weight of straw per plant, there was a great variation in the four cultures made, but it was only in the first culture (see table 1) where there was a significant difference between the vine yields of the new and old seeds in favor of the latter. The straw yields per plant of the new and old seeds were 11.36 ± 0.55 and 21.86 ± 2.03 grams, respectively. In the third culture, the old seeds produced less vine than the new seeds but the difference was nevertheless insignificant (see table 3). In the last culture (see table 4) the old seeds gave slightly heavier yield of vine.

In the weight of the root system as determined in the third culture (see table 3), while the old seeds produced heavier root system, the difference could not be considered biometrically significant. The plants from old seeds produced 3.45 ± 0.19 grams per plant of dry roots while those from new seeds gave 3.20 ± 0.14 grams per plant.

Yield of pods.—Unlike the yield of vine, there was a significant difference between the yields of pods, both in number and in weight, of the new and old seeds. In all the cultures, except the last, in spite of the great variation in pod yields, the old

seeds gave greater pod yield. In the first culture, the new seeds produced 9.00 ± 0.74 pods per plant and the old seeds, 17.80 ± 1.56 pods per plant, while in the third culture the number of pods produced per plant of the new seeds was 11.06 ± 0.50 and 17.39 ± 0.59 pods per plant for the old seeds.

Yield of beans.—The effect of the age of the mungo seeds planted on the yield of bean was similar to the effect on the yield of pod. In the first culture, the bean yields per plant of the new and old seed were 3.23 ± 0.31 and 6.83 ± 0.78 grams, respectively; in the second culture, 1.33 ± 0.05 and 1.73 ± 0.06, respectively; in the third culture, 5.33 ± 0.27 and 8.39 ± 0.29, respectively; and in the last culture the corresponding bean yields were 1.64 ± 0.13 and 1.58 ± 0.11 grams per plant (see tables 1, 2, 3 and 4). In all the cultures, except the last as in the case of the pod yield, the bean yield of the old seeds was decidedly greater than that of the new seed, the former outyielding the latter by 30 to 110%. In the last culture, however, the pod and bean yields, respectively, of the new seeds were slightly greater although the difference was negligible. It may be remarked, however, in this connection that the poor showing of the old seeds in this culture might have been due to the effect of the typhoon during the blooming period of the plants. Because of the greater height of the plants from the old seed, as shown in table 4, it is probable that the effect of the typhoon was more severe on the more vigorous plants resulting in decreased pod and bean yields.

The results thus far obtained show some strong evidence of the existence of certain phenomena in stored seeds that are worthy of conscientious and critical study. The behavior of the old seeds as manifested in this work may be explained as follows: Either the vigor (expressed in yielding power) of the seed is correlated with its inherent longevity; or the seed requires certain "seasoning" or "curing" before it is capable of attaining the peak of its vitality.

In the first case, since variation even within a pure line is universal, it may be expected that the seeds vary in their ability to keep their viability while in storage. It is probable that seeds which do not keep their viability long are not also vital. So that what seems to be accomplished in prolonged storage is that the weak and poor seeds lose their viability first and thus are naturally eliminated while the vital and productive ones remain viable.

Since the difference in yield in some of the cultures, especially the first, was so great, it appears that the difference in yield may be caused by other factors. It is also probable that the seed before it is capable of giving its best yield, goes first through a certain stage of "seasoning" or "curing" in the same way that budding or grafting requires certain definite maturity of the scion or stock before the best results can be obtained. The phenomenon which seems to cause renewed vigor or vitality is being manifested in other ways in the life of both plants and animals. For example, the writer(3) in his study of the longevity of some farm crop seeds found renewed vigor in some of the seeds he studied as expressed in the increased percentage of germination. Also, this fact was recognized by some early writers, for in 1859, Bartlett(1) reported "that cabbage, turnip seed, etc., keep well for several years, and are more to be depended on in producing those varieties in perfection than those of more recent production".

This phenomenon in the mungo seed has a far-reaching significance. For, if this holds true with other crops, the right "seasoning" or "curing" treatment may be worked out with the different crops so as to effect some increase in vigor and in production.

In this connection, it may be pointed out that the suggestion made by the writer(3) as to the possibility for "plant breeders who are testing a large number of varieties under limited means . . . . to store part of their materials to be tested gradually in later years" is not possible because of the fact brought out by this study that old and new seeds of the same variety or strain vary in their ability to develop and produce fruits or seeds.

SUMMARY

1. In this study some interesting data on the comparative vigor of new (one-month-old) and old (11- to 13-year-old) mungo seeds expressed in the yields of vine, pod, and bean were obtained.

2. The yield in straw of the old and new mungo seeds did not vary much, although it was slightly in favor of the old seeds. However, the old mungo seeds gave decidedly greater yields of pods and beans than the new seeds.

3. The results obtained show some evidence of the existence of certain phenomena in seed in storage that are worthy of a conscientious and critical study. It is strongly evident that the

seed seems to require a certain degree of "curing" or "seasoning" before it is capable of attaining the peak of its vitality. This may vary with different crops and should be thoroughly studied so as to take advantage of its economic value.

LITERATURE

1. Bartlett, Levi. Vitality of seeds. Report of the Commissioner of Patents for the year 1858: 332–333. Washington, D. C. 1859.
2. Duvel, J. W. T. Vitality and germination of seeds. U. S. D. A. Bull. 58 (1904).
3. Rodrigo, P. A. Longevity of some farm crop seeds. Phil. Jour. Agr. 6 (1935) 343–357.
4. Vibar, T. and P. A. Rodrigo. Storing farm crop seeds. Phil. Agr. Rev. 22 (1929) 3–14.
5. Sonavne, K. M. Longevity of crop seeds: I. Agric. Jour. India 23 (1928) 271–276.
6. ———. Longevity of crop seeds: II. Agric. and Livestock in India 4 (1934) Part 3, 287–292.

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ILLUSTRATIONS

Plate I

Fig. 1. Pot cultures (second culture) of (1) new, and (2) old seeds of mungo. The difference in stand is slight.

2. Typical plants arising from (1) new, and (2) old mungo seeds. Note the difference in size and number of pods produced.

1

2

PLATE 1.

POT CULTURE EXPERIMENTS ON CABBAGE

By Julian A. Agati and P. A. Rodrigo
Of the Bureau of Plant Industry

ONE PLATE

Heretofore, the common practice of applying fertilizers to commercial cabbage cultures in the Philippines was based upon practical experience. In Baguio and Trinidad Valley, Mountain Province, where cabbage is grown not only most extensively but also intensively, the common practice is to apply a mixture of fertilizers consisting of about 6 parts of stable manure or compost, 3 parts of soybean cake and fish meal and one part of potash and phosphorous fertilizers(4). This is used as a basic fertilizer and is later supplemented with several doses of ammonium sulphate in solution [1] during the development of the plants.

Whether this is the best combination for cabbage, there are no available data to show it. Recently, however, some attempts have been made to use different brands of fertilizers, consisting of combinations of nitrogen, phosphate and potash, in cabbage culture. For example, Gutierrez(2), in his experiments, used different brands of fertilizers containing nitrogen, P_2O_5 and K_2O in different proportions. Unfortunately, in these studies, the three manurial elements (N, P, and K), were not applied singly. Neither was each element applied in the same amount. Thus, it could not be stated with certainty that the increases in yields were due to a certain element or combination of elements.

The fertilization of cabbage in the Philippines undoubtedly calls for further experimentation. One of the problems at present confronting the cabbage growers consists in finding a certain combination of two or more of the inorganic fertilizers in the market with the object in view of improving the yield and the quality of the marketable heads. The present pot culture studies aimed (1) to determine the effect of using ni-

[1] One canful (milk can, pint size) of ammonium sulphate is dissolved in one petroleum canful (20 liters) of water, and this is utilized to water about 100 to 200 plants.

trogen (N), phosphoric acid (P_2O_5) and potassium oxide (K_2O) singly at different rates on the stand and yield of cabbage, and (2) to find out the optimum amount and combinations of fertilizers of a certain standard formula which not only outyield the single fertilizer but give a quality product as well.

The study was undertaken during the vegetable season of 1937–1938 at the Central Experiment Station, Malate, Manila.

MATERIALS AND METHODS

For this experiment, 110 big earthen pots measuring 15 inches, top diameter, 12 inches high, and 12 inches, bottom diameter; sandy loam soil with a pH reaction of 6.23;[a] and seedlings of Early Flat Dutch cabbage of uniform age and size, were used.

The soil was thoroughly mixed and pulverized before transferring it into the pots. The pots were arranged in rows of eight. Excepting the first row which included only 5 pots, the other rows consisted of 15 pots, each. The first row received no treatment; it was used as a check. The second row was treated with nitrogen, the third with nitrogen and phosphoric acid, the fourth with nitrogen and potassium oxide, the fifth with nitrogen, phosphoric acid and potassium oxide, the sixth with phosphoric acid, the seventh with potassium oxide, and the last row with phosphoric acid and potassium oxide. Each of the fertilizers used was applied in three different amounts, viz., minimum, medium, and maximum. The minimum application consisted of 500 kg. of fertilizers per hectare; the medium amount was applied at the rate of 750 kg. per hectare; and the maximum rate was applied at the rate of 1,000 kg. per hectare. These rates of application bore the formula 8-12-4, that is, it contained 8 per cent nitrogen, 12 per cent phosphoric acid, and 4 per cent potassium oxide. This was found suitable under Rhode Island conditions(3). Ammonium sulphate supplied the nitrogen, superphosphate of lime the phosphoric acid, and potassium sulphate the potassium oxide. For each of the individual rates of application of the fertilizers enumerated above, five pots were used.

One seedling, about 40 days old, was planted in each pot. The fertilizers were applied one day after transplanting.

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[a] Nitrogen (N)—0.057 per cent; phosphoric anhydride (P_2O_5)—0.215 per cent; lime (CaO)—0.472 per cent; potash (K_2O)—0.097 per cent; magnesium (MgO)—1.27 per cent (analysis by R. Isidro).

Care was taken to maintain the moisture in each pot at optimum condition, that is, the soil was kept sufficiently moist so as to avoid the wilting of the plants.

The experiment was carried till harvest time. At the termination of the experiment, the height of the individual plants, the gross weight, and finally the weight and size of the marketable heads were recorded. These were used as criteria in evaluating the fertilizers employed.

The use of pot cultures seems justifiable since this method is not only less expensive and easy to handle but also gives a fairly reliable index for further experimentation in the field as found in Hawaii(1).

RESULTS OF THE EXPERIMENTS

About a week after the application of the fertilizers, their effects began to manifest themselves. All the plants that had nitrogen treatment were dark green in color and showed vigorous growth, while those that did not receive any nitrogen had poor growth, like the check plants. The plants treated with P_2O_5 and K_2O, either singly or in combination, did not produce any marketable heads. Table 1 gives the average results of the experiments while table 2 presents the summary of the results obtained.

DISCUSSION OF RESULTS

Inasmuch as the results obtained from the use of P_2O_5 and K_2O, or a combination of both, and the controls, respectively, did not yield any marketable heads at the close of the experiment, they are not considered in the present discussion. Neither the heights of the plants are taken up since they least affect the economics of the experiment. One outstanding fact derived from the results of the experiment is the apparent limiting effect of nitrogen. All the treatments in which nitrogen was included gave marketable heads. Considering first the results obtained with this treatment, it is striking to note that the total weight of heads, and the average weight of heads, respectively, were greater with the minimum application than with the maximum application. This variation may show that the practical effects of minimum rates of application are comparable to those of the maximum rates. This seems to be at variance with the findings of Rodrigo(5) that the yield was more or less proportional to the rate of ammonium sulphate applied. However, if the circumstances surrounding the experiment are to be con-

TABLE 1.—*Average results of fertilizer experiments on cabbage.*

Fertilizers used		Height of plants		Gross weight of plants		Diameter of head		Weight of marketable head		Thickness of head		Volume of water displaced		Sp. Gr.
Kind	Amount per hectare	Total	Average	Total	Average	Total	Average	Total	Average	Total	Average	Total	Average	
	kg.	*cms.*	*cms.*	*grams*	*grams*	*cms.*	*cms.*	*grams*	*grams*	*cms.*	*cms.*	*cc.*	*cc.*	
NPK	1,000	96.8	19.36	3,313.2	675.25	44.0	8.80	1,714.0	342.80	57.4	11.48	1,514.0	302.8	1.13
NPK	750	93.7	18.74	2,993.6	598.72	44.2	8.84	1,635.1	327.1	58.9	11.78	1,677.7	395.54	1.10
NPK	500	87.4	17.48	2,171.1	434.22	45.7	9.14	1,179.9	235.98	53.3	10.66	1,057.4	211.58	1.11
NP	1,000	96.9	19.38	2,934.0	586.80	42.2	8.44	1,441.4	288.28	54.20	10.84	1,091.0	218.20	1.32
NP	750	95.0	19.0	2,654.6	530.92	45.1	9.02	1,635.8	327.16	56.60	11.3	1,421.0	284.20	1.15
NP	500	90.8	18.16	2,401.5	480.30	41.5	8.30	1,424.1	284.82	53.8	10.76	1,345.0	269.00	1.05
NK	1,000	86.6	17.32	2,354.6	470.92	44.8	8.96	1,420.7	284.14	52.3	10.46	979.0	195.80	1.45
NK	750	86.6	17.32	1,984.5	396.9	41.2	8.24	1,096.6	219.32	51.1	10.22	883.0	176.60	1.24
NK	500	93.9	18.78	2,231.5	446.3	39.6	7.92	1,206.6	241.32	52 6	10.52	895.0	179.0	1.34
N	1,000	91.6	18.32	2,103.8	420.76	41.1	8.25	986.2	197.24	38.7	7.74	663.0	132.6	1.48
N	750	84.0	16.80	1,698.5	339.60	39.8	7.96	930.4	186.08	45.5	9.10	661.0	112.2	1.65
N	500	91.3	18.26	1,964.3	392.86	42.7	8.54	1,129.5	225.90	49.2	9.85	718.0	143.0	1.57
K	1,000	76.63	15.26	266.4	[a] 53.28									
K	750	76.4	15.28	230.2	[a] 46.04									
K	500	63.8	12.76	201.4	[a] 40.28									
P	1,000	74.6	14 92	222.5	[a] 44.4									
P	750	70.5	14.10	256.9	[a] 51.38									
P	500	72.5	14.50	214.8	[a] 42.96									
PK	1,000	73.2	14.64	302 0	60.40									
PK	750	70.4	14.08	273.4	54.68									
PK	500	70.2	14.04	216.3	43.26									
Control	[b]	74.2	14.85	243.4	[a] 48 68									

[a] The plants were more or less stunted in growth and did not produce any head.
[b] No fertilizers.

TABLE 2.—*Summary results of the pot fertilizer experiments on cabbage.*

Amount of fertilizer per hectare	Criteria used	Fertilizing elements used							
		N	NP	NK	NPK	PK	P	K	Control
Kg.									
500	Average weight of plant in kg.	0.39 ±0.021	0.48 ±0.020	0.45 ±0.030	0.43 ±0.020	0.04 ±0.004	0.05 ±0.003	0.04 ±0.003	0.049
	Average weight of head in kg.	0.20 ±0.008	0.28 ±0.030	0.28 ±0.030	0.24 ±0.020				
	Percentage of heading	100	100	100	100		0	0	0
750	Average weight of plant in kg.	0.34 ±0.019	0.53 ±0.030	0.39 ±0.012	0.60 ±0.020	0.05 ±0.003	0.05 ±0.003	0.05 ±0.003	
	Average weight of head in kg.	0.18 ±0.016	0.33 ±0.012	0.21 ±0.02	0.33 ±0.015				
	Percentage of heading	100	100	100	100		0	0	0
1,000	Average weight of plant in kg.	0.42 ±0.012	0.59 ±0 020	0.47 ±0.030	0.68 ±0.020	0.06 ±0.008	0.04 ±0.003	0.05 ±0.003	
	Average weight of head in kg.	0.23 ±0.017	0.29 ±0.020	0.26 ±0 020	0.35 ±0.009				
	Percentage of heading	100	100	100	100		0	0	

sidered, these variations are rather an exception to the rule. Since nitrogen is known to be greatly soluble, it seems not unlikely that part of it is liable to be lost through leaching or splashing during rainy days. Moreover, the time of application may also affect its availability to the plants, so that when the application is not done in the most opportune time(6) the plants will not derive the whole benefit from the treatment. These two factors seemed to have been at work in the present instance.

Similarly, in the case of nitrogen and phosphoric acid, although the gross weight of heads was apparent with the maximum rate of application, the maximum average weight of the marketable heads was obtained with the medium application of fertilizers. This was also true in the case of the combination of nitrogen and potassium oxide. Thus, although the average gross weights of heads varied proportionately with the treatment, the weight of the marketable heads did not follow exactly the same trend. The minimum rate of application gave even better results than the medium rate, as shown both by the gross weights of heads and the weights of marketable heads.

Considering the results as a whole, it is evident that both nitrogen and phosphoric acid, and nitrogen and potassium oxide, respectively, gave better yields than the nitrogen alone. This shows that the addition of phosphoric acid and potassium oxide, respectively, to nitrogen produced a stimulating effect on the plants, as shown in the yield. This may also suggest the advantage of complete fertilizers. The results obtained by using a combination of nitrogen, P_2O_5 and K_2O bear out this fact. The yields obtained with the use of the complete fertilizers were generally greater than those obtained with either a combination of nitrogen and P_2O_5 or nitrogen and K_2O.

Although the results obtained from the use of NPK were generally better than those obtained from single or other combinations of fertilizers, it cannot be entirely said that its use is profitable without first considering both the production cost and the income.

There seems to be some degree of certainty that the present method of fertilizing cabbage can still be improved upon or modified by using nitrogen with P_2O_5 and K_2O in different proportions or combinations. While the production cost will undoubtedly increase, the income is bound to increase proportionately. Perhaps if a certain combination could be evolved following the trend to which the present experiments apparently lead,

and production cost could be kept at minimum levels, the culture could be made to yield returns that will give an edge to the farmer. The results from the pot cultures will constitute a fair index for further experimentation in the field. A follow-up field test will be conducted in the future.

SUMMARY

1. The present paper consists of pot culture studies using nitrogen (N), phosphoric acid (P_2O_5) and potassium oxide (K_2O) singly, and combinations of nitrogen and P_2O_5, of P_2O_5 and K_2O, and of nitrogen, P_2O_5 and K_2O applied at different rates.

2. The use of nitrogen and P_2O_5 and that of nitrogen and K_2O is better than nitrogen alone, showing the advantageous effect of combining nitrogen with these elements.

3. The treatment with a combination of nitrogen, P_2O_5 and K_2O did not only give the greatest gross weight of heads but also the greatest weight of marketable heads.

4. In some cases the yields did not increase proportionately with the rates of application of fertilizers.

5. The results obtained from the present pot culture studies gave a fair index for future tests in the field.

LITERATURE CITED

1. Anonymous. Annual Report of the Hawaii Agric. Expt. Station, 1933, pp. 12–13. Honolulu, Hawaii, 1934.
2. Gutierrez, M. E. Progress report of cabbage experiments at Baguio, Mountain Province. Phil. Jour. Agr. 9 (1938) 79–102.
3. Hartwell, B. L. and F. K. Crandall. The substitution of stable manure by fertilizers, green manures and peat. R. I. Expt. Sta. Bull. 188 (1922).
4. Rodrigo, P. A. A survey of the vegetable industry in Baguio and in Trinidad Valley, Mountain Province, Luzon. Phil. Jour. Agr. 4 (1933) 179–199. 2 pls.
5. Rodrigo, P. A. The effect on the yield of cabbage of different amounts of ammonium sulphate. (Unpublished.)
6. Rodrigo, P. A. The effect on the yield of cabbage of applying ammonium sulphate and aëro cyanamid at different stages of growth. (Unpublished.)

ILLUSTRATIONS

Plate 1

Fig. 1. A view of the pot cultures about three weeks after the application of the fertilizers. Note the vigor of the plants that received nitrogen treatment.

2. A view of the same pot cultures taken a few days before harvest. Marketable heads were obtained from plants that received nitrogen, either singly or in combination.

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PLATE 1.

SILKWORM CULTURE IN THE PHILIPPINES[1]

By

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and

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The Philippines import silk and its manufactures worth several millions of pesos annually. Our climate and soil are favorable to the growing of mulberry trees (*Morus alba* Linn.), and we have wide tracts of land that can be planted to mulberries. Labor is available, but it needs some training before it can tackle the different phases of silk raising. These factors, together with a comparatively small capital necessary to start it, make silkworm raising an attractive household industry.

The importation of silk and its manufactures, both natural and artificial, into the Philippines from the United States, Japan, China, and other countries is given in table 1.

TABLE 1.—*Importation of silk and its manufactures into the Philippines, from 1926 to 1937*

Year	Value
1926	₱7,092,855
1927	7,960,729
1928	8,512,739
1929	9,328,442
1930	8,650,820
1931	6,461,561
1932	4,901,256
1933	4,020,186
1934	4,603,650
1935	4,851,400
1936	5,764,409
1937	6,195,701
Average	₱6,528,645.77

[1] Farmers' Circular No. 19.

MULBERRY CULTURE

The mulberry plantation should be well established before the raising of silkworms. The plantation should not be located in a place exposed to strong winds but near the site of the silk house. Mulberry thrives in almost any kind of soil having proper drainage. Rocky or stony soil which is unfit for most economic plants may be utilized. It is generally propagated by means of stem cuttings. Cuttings 15 to 20 centimeters in length should be taken from two- to three-year-old trees and should first be planted in seedbeds prepared like garden plots or direct in the plantation at the beginning or the latter part of the rainy season. Cuttings having three or more tiny buds within the leaf axils are recommended. When the shoots are about 20 centimeters long, they may be planted permanently in the plantation. After attaining a height of one meter, they should be pruned so as to produce more lateral branches and consequently more leaves. Intercropping the young mulberries with leguminous crops is recommended as a source of additional income. Mulberries should be planted three meters apart.

SILK HOUSE

The silkworms should be raised, if possible, in a rat-proof, ant-proof and lizard-proof house. The silkhouse, like the mulberry plantation, should not be exposed to strong winds and it should be located far away from dusty roads as much as possible. Dust carries micro-organisms and is a source of infection to the silkworms. The upper portion of the walls may be made of wire gauze, screen, "sinamay" or abacá cloth used for making sacks, and the ceiling, preferably of abacá cloth which is cheaper. The lower or basal portion of the walls may be made of "sawali," plain galvanized iron, or board. The roof may be of nipa but it should be rain-proof. The legs of the racks, which hold the trays in which the worms are reared, should rest on small pans with water, or else provided with some repellant that keeps ants away from the worms. One simple method of keeping the worms away from other insects is to apply tanglefoot on the legs of the racks or wrap them around with cloth wet with petroleum or crude oil. A convenient tray for the worms is one with the dimensions 43 $\times$ 90 $\times$ 1.5 centimeters with the frame made of wood or bamboo.

CULTURAL DIRECTIONS

The eggs hatch about seven to eight days after they have been laid. "The tenderest, young, green leaves which have become nearly expanded and are still of a very pale hue and which are taken from the tips of the mulberry shoots should be given at this stage, but those which are not as yet unfolded should be avoided." The leaves should be placed within the reach of the larvae. The newly hatched larvae crawl and feed on the leaves. The leaves with the young worms are transferred to other trays. Then they are given the proper feeding by distributing thinly chopped mulberry leaves over them. If the leaves are too dry, they should be changed. As the larvæ grow older or bigger they should be given older leaves. The best rule to follow is "age of leaves to the age of silkworms." Plate 3 shows the age of leaves to be given to the worms at different instars. The larvæ should not be touched with the fingers but with a soft hair brush or a pair of fine-pointed bamboo pincers.

From four to six feedings at intervals of three hours are required daily from 6 o'clock in the morning to 6 o'clock in the evening. Dead larvae and decaying feeds should be removed immediately and before fresh feeds are given, otherwise they might cause an epidemic to the worms. Changing of beds where the excrements and the unconsumed feeds accumulate should be done daily especially during damp weather.

While the larvae are molting they should not be given any feed. The signs of molting are a "cessation of feeding, a general appearance of fullness, an elevation of the forward third of the body, a drawing together of the forward three pairs of legs, the assuming of the sphinx-like attitude, and the extremely small size of the head as compared with the rest of the body." The space occupied by the worms is doubled after each molting. The worms should be grouped according to age or size. Smaller worms resulting from poor development or late molting should be removed and grouped or placed separately.

In the fourth and fifth instars, the worms may be fed with "fully matured leaves, not hard, dry leaves which are on the verge of dropping from the plant, but fully expanded, dark-colored, glossy leaves of a rough feel, and which are free from sand, dust, and mold."

At the fifth instar, the body of the silkworm is plump, buff grayish white, turning to a translucent yellow, a day or two before it begins to spin. "A silkworm first indicates that it is about to spin by ceasing to eat, protruding its head, and beginning to reach around as if looking for something." When the worms show these signs they are ready to spin and may then be brought to the spinning place. The spinning place may be of wire baskets or a box containing suitable materials for pupation. Dry grass, cogon leaves, rice straw, abacá tow or similar materials are arranged loosely in the box or wire baskets for the spinning place.

Three days after the pupation, the cocoons may be taken out and the best ones are selected for further breeding purposes while the rest may be reeled at once and used for spinning silk. The earliest cocoons are reserved for breeding purposes. A good rule to follow is to select "twice as many large cocoons as desired for females and the same proportion of small- and medium-sized ones in order to get a fairly large number of males." If the cocoons are to be kept for shipping or if they cannot be reeled immediately, they must be killed by steam or dry heat (sun drying).

The cocoons for reproduction are pasted to a tray lined with Manila paper or abacá burlap or buri raffia mat (*dait*) to keep them in place. When the moths emerge, they should be isolated in order that copulation may be controlled.

Only the most vigorous females and those having the largest abdomen should be selected for egg reproduction. The males which are energetic and have perfect bodies and wing formations should be used for breeding purposes. When the wings of the moths are thoroughly dry, copulation for two hours is necessary to insure fertilization of all the eggs. After copulation, the females are placed singly on a small piece of paper and a ring of bamboo or cardboard two to three centimeters high is put around to protect them while laying eggs.

PRESERVATION OF COCOONS

Cocoons should be thoroughly dried before storing them for the market. They should be protected from ants. The simplest method of storing the cocoons is to place them in thin tin vessels with tight fitting covers. In large scale storing, the dried cocoons are placed in bags of thick moisture-proof paper.

LIFE HISTORY

The following data on the life of the Bengal-Ceylon silkworm were obtained at the Central Experiment Station, Manila, by the Entomology Section, Plant Pest and Disease Control Division:

Egg stage	7 to 8 days
Larval stage	10 to 24 days
Molts, four times	
1st Instar	3 to 4 days
2nd Instar	3 to 4 days
3rd Instar	3 to 4 days
4th Instar	3 to 5 days
5th Instar	5 to 7 days
Spinning of cocoons	About 2 days
Pupal stage	8 to 10 days
Adult stage	2 to 5 days
Female moths lay eggs about 12 hours after emergence	
Number of eggs laid by each female	300–450
Life cycle (egg to adult)	38–45 days
Number of generations in one year	8–9

REFERENCES

1. ANONYMOUS: Possibilities of the silk industry in the Philippines. Bureau of Commerce. Manila.
2. Annual report of the Insular Collector of Customs. 1926–1937. Department of Finance.
3. BANKS, CHARLES S.: A manual of Philippine silk culture. 1911. Manila: Bureau of Printing.
4. OLIVER, GEORGE W.: Silkworm food plants. U. S. D. A. Bull. 34.

ILLUSTRATIONS

PLATE 1

FIG. 1. Silkworm cocoons.
2. Pupae inside the cocoons.

PLATE 2

FIG. 1. Copulating moths.
2. Eggs.

PLATE 3

Mulberry leaves of different stages for the larvae of different instars.

PLATE 4

FIG. 1. A tray where worms are reared.
2. A rack where the trays are placed.

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PLATE 1.

1

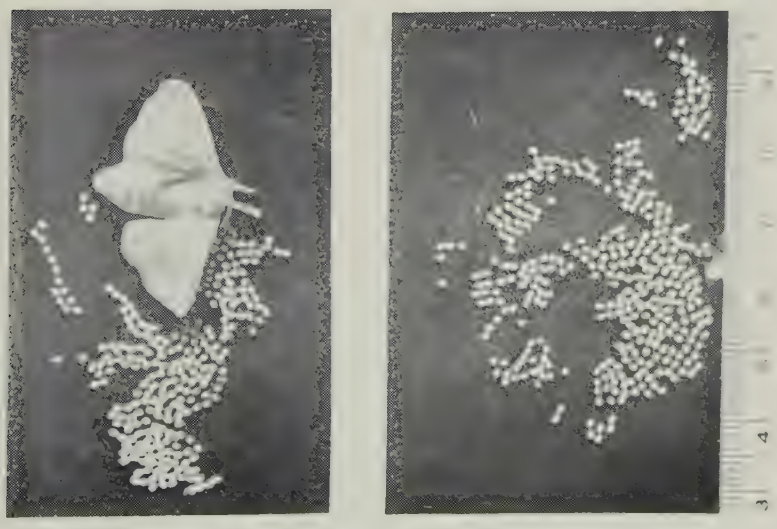

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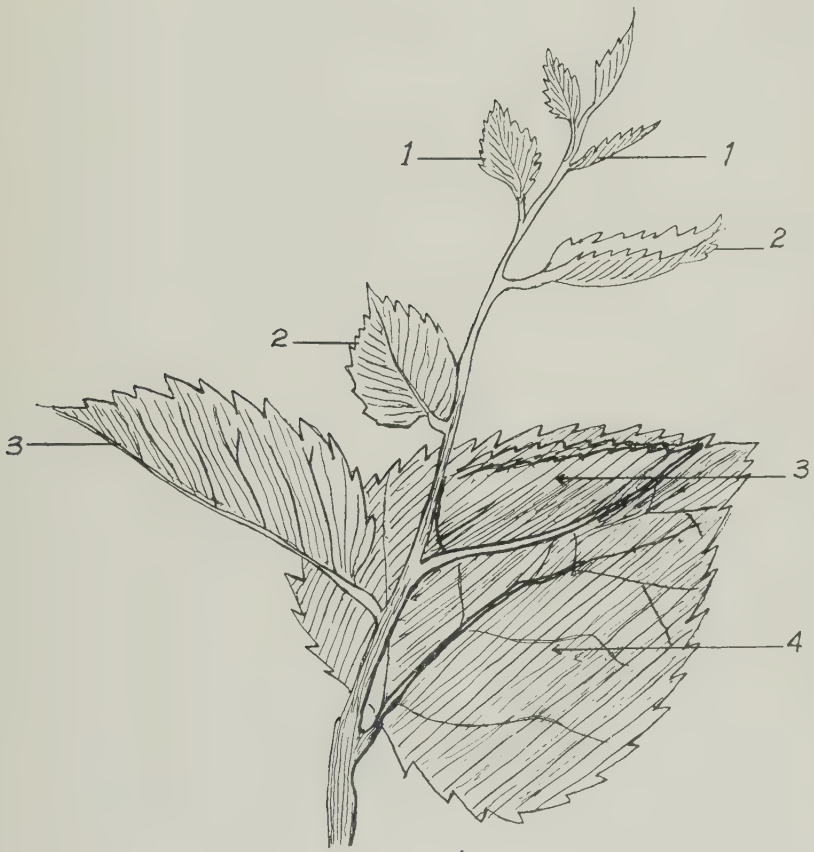
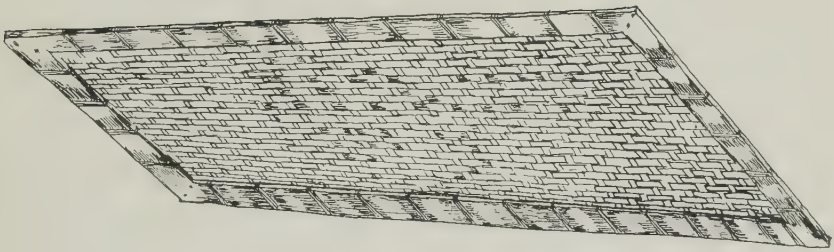
PLATE 2.



1.1.- Leaf for young worms
2.2.- For worms after 1st molt
3.3.- " " " 2nd "
4.- " " " 3rd "

After Percy N. Braine

PLATE 3.



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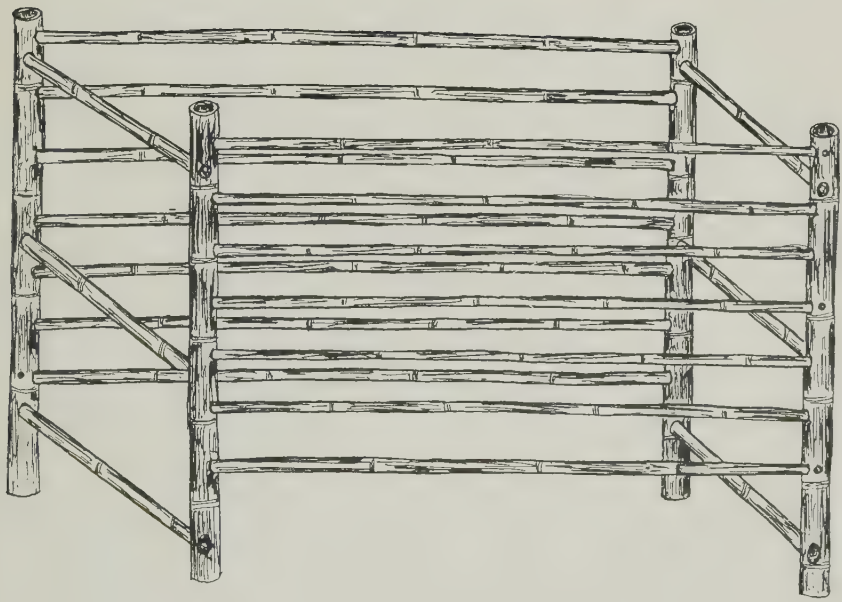

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PLATE 4.

BATEK LEAF TOBACCO CULTURE IN THE PHILIPPINES [1]

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Choice of varieties.—Any good variety for cigar filler is also good for batek production. The Vizcaya, Simmaba, and Marogui, however, are the best suited for batek culture because of their size.

Soil requirements.—Sandy loam soils which are exceedingly fertile and well-drained are ideal for batek culture.

Climatic requirements.—Regions with well-defined dry and wet seasons like La Union and Pangasinan are the principal batek-tobacco-producing provinces. However, Laguna with short dry period has been proven to grow good-quality batek. This being the case, even the Cagayan Valley might be suited for batek culture.

The optimum seasonal periods of field operations for batek tobacco are the same as those for wrapper culture, viz.:

1. Sowing of seeds	October 1–15
2. Transplanting	November 25 to December 15
3. First harvest (liso)	January 25 to February 5
4. First harvest (batek)	February 25
5. Curing period	30 to 45 days
6. Number of harvests (priming)	4 to 5 times

The above schedule of field operations is applicable under La Union, Pangasinan, and Laguna conditions, and in places with similar climatic conditions.

Location and preparation of seedbeds.—Well-drained, loamy and fertile sections of the field near a good water supply should be selected for seedbed purposes. The ground is plowed and harrowed thoroughly in September and October and after-

[1] Farmers' Circular No. 18.

wards divided into plots each with an area of one meter by ten meters. The plots should be laid lengthwise from north to south instead of from east to west. A path of about half a meter wide should separate the plots. These paths will serve as drainage and passageways. The soil dug from the path should be deposited on the plots thus formed to elevate them. Each bed is provided with an inclined portable shed to protect it from strong rain and sunshine. For covenience, the shed should be a meter high at the front and about sixty centimeters at the rear in order to admit the morning sun into the beds, but not the afternoon sun. The most suitable materials for seedbed sheds are bamboo for frame, and talahib, cogon grass, nipa shingles or abacá cloth for shed cover.

The final preparation of the seedbeds preparatory to sowing should be aided by the use of garden tools like the rake and the hoe. The debris is removed and the soil is well pulverized and leveled accordingly by making the edges of the beds a little higher than the center.

Sowing of seeds.—Sow only seeds of high viability. This can easily be determined by germinating a few seeds between pieces of moist blotting paper and then counting the number of seeds that germinate and those that fail to germinate. If the percentage of germination is not lower than seventy per cent then the seed is still good for sowing. For every bed of one meter by ten meters, five grams of seed is sown. This amount can be placed in two-thirds of a one-centavo match box. The seed is mixed with two chupas of well-sieved wood ash as the seeds are hardly visible. The evenness of the wood ash over the beds is a direct indication of the even distribution of the seeds.

A bed of the size mentioned above will produce no less than a thousand seedlings, so that ten beds will be about enough to provide seedlings for a hectare of batek tobacco.

Newly sown seeds are frequently attacked by ants. To protect the seeds from being carried away by ants, it is well to scatter sweetened ground corn as bait around the borders of the beds.

Care of seedlings.—After the seeds are sown the surface of the beds is made firm by the use of a wood plank. This will keep the seeds from being blown or from being washed out during watering. The beds should be kept moist every day but not damp. The seedlings will come up within seven to ten days. Newly germinated seedlings should not be disturbed until they

have two pairs of leaves. When the seedlings reach this stage then weeding can be started and done every now and then to keep the beds free from weeds. Crowded areas should be thinned out by pulling some of the seedlings. The damping-off is a frequent disease in the seedbed. When this disease occurs, the infected seedlings, including the soil, should be removed, and the infected area treated with 5 per cent formaline solution.

Fifteen to twenty days after germination the shelter of the beds can be removed to allow the seedlings to grow in the open. This will make them sturdy and thus easily recover when transplanted in the field.

Preparation of the field.—The field is first cleared of bushes, stumps and weeds before it is plowed and harrowed thoroughly crosswise until it is well pulverized. One day before transplanting, the furrows are laid about a meter apart. Then cross furrows are laid eighty centimeters apart. The native plow is very appropriate for laying the furrows.

Transplanting.—Forty-five to sixty days after sowing, the seedlings will be ready for planting. The seedbeds are sprinkled with water to soften the ground before the seedlings are pulled. This will lessen the breakage of the root system. Only uniform and healthy seedlings should be utilized for transplanting. A hole sufficiently deep to accommodate the entire root system of the seedling is dug at the intersection of the furrows. The seedling is laid carefully in the hole standing upright while the roots are covered with soil. This done, the newly transplanted seedling is watered to have an easy start.

Cultivation.—Cultivation begins as soon as the plants have fully recovered. The first cultivation is done with a trowel by loosening the ground around the plants and heaping the soil around the stem. This method of cultivation is done regularly until the plants are about a foot high. Then the plow is used next by passing it between the rows and turning the soil over along the row, gradually converting the rows of plants into ridges. Two to three plow cultivations besides the first hand cultivation usually are sufficient. By the time the last plow cultivation is completed the plants will then have from eight to twelve leaves.

Worming.—From the time the plants are set in the field worm-picking becomes a daily routine job in the plantation. The worms are the most destructive enemy of the tobacco in the

field. The batek, being a fancy crop, should be free from any unsoundness. In cigar filler and wrapper tobacco production, the use of arsenical mixtures for worm control is often resorted to. In batek tobacco production the use of same is not indispensable. Hand picking is more efficient specially when the plants are already topped.

Topping and suckering.—Topping is done when the plants have developed eight to twelve leaves by pinching the bud. The plant, being still very young and at its most vigorous stage of growth, naturally nourishes the remaining leaves. Suckers which invariably follow topping should be removed as fast as they appear to insure maximum development of the leaves.

Harvesting.—The sand leaves are harvested as *liso* (cigar filler) tobacco and are usually primed after the last cultivation. Batek leaves ready for harvest, however, should bear the characteristic brown spot which means that the leaves have reached full ripeness. The appearance of the spot is gradual, appearing first as faint yellowish coloration and becoming more pronounced as the leaves mature and turning eventually into brown, lifeless spots in the leaves. Usually two leaves are picked every priming. The leaves are brought to the curing barn and classified as to length preparatory to sticking. Harvesting is done in the morning so that sticking can be performed during the hot hours of the day. After all the batek leaves have been harvested the plants are allowed to develop suckers for the further production of *liso* tobacco.

Poling or sticking.—The sand leaves which are *liso* (cigar filler) tobacco are sticked or poled as the ordinary cigar filler crop, but the batek leaves are poled in an entirely different manner. The batek leaves are stuck by passing the sharpened end of the palillo through the petiole of the leaf. This is done in such a manner that the leaves are placed back to back with their upper surfaces exposed. Strong sticks (palillos) should be used as the leaves are big and heavy. The stuck tobacco are placed on the racks ready to cure.

Curing shed and the curing operation.—A good curing barn for cigar filler or cigar wrapper tobacco is also good for curing batek tobacco. The ordinary practice of wilting the cigar filler leaf tobacco in the sun is dispensed with in the case of batek tobacco. Good ventilation should be provided as the crop is cured purely by the action of air. The barn should be closed during the first three to five days of curing, and gradually opened

thereafter, until the leaves and midribs are thoroughly dried or desiccated. Curing lasts from 30 to 45 days, depending upon weather conditions and the size and thickness of the leaves. The crop is completely cured when the midrib, which dries last, is free from sap.

Bunching and fermentation.—Thoroughly cured leaves are taken down from the racks early in the morning, removed from the palillos and assorted as to size. After sorting, the leaves are ready to be bunched or made into hands. A small stick about a foot long is passed through the holes of the petioles of 20 leaves with their laminae spread flat and overlapping each other. Five of these small palillos are then piled one over the other to form a hand of one hundred leaves. The hand is tied with buri leaf strips at the basal, middle, and apical regions, after which it is ready for storage in big boxes for fermentation and aging processes.

Preparation of product for market.—A month or two after storage the crop is ready for sale. If the crop is sold as a whole, the transaction would be on the quintal basis and buyers would base their offer on the estimated percentage of big-sized hands present in the whole lot or *partida.* If the percentage of big-sized hands is high better prices are offered. If the crop is sold by the hand or even by the leaf, the big hands or leaves command higher prices. Batek tobacco commands a much higher price than the cigar filler type. The characteristic spots of batek tobacco do not really play an important role in its sale. What is most important is that it should be thick and strong. Incidentally, cigar filler tobacco leaves are obtained from the sand leaves and suckers of batek tobacco which are, as a rule, of medium texture.

ERRATA

THE GRANJA SUGAR CANE EXPERIMENT STATION, by Juan B. Cabanos, Vol. 10, No. 1:

Page 38, third paragraph. Substitute the following statement: "The West Negros district is seldom visited by destructive typhoons and, therefore, rarely receives the hazards of destructive storms and floods."

Page 38, Table on rainfall and meteorological readings, column 4, line 2. Read *117.13* instead of *17.13*.

Supra, line 3. Read *109.79* instead of *9.79*.

Supra, columns 5, 6 and 7, omit.

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AGRICULTURAL STATIONS AND SEED FARMS

1. Central Experiment Station, Manila
2. Lamao Horticultural Station, Limay, Bataan
3. Lipa Coffee-Citrus Station, Lipa, Batangas
4. Gandara Seed Farm, Gandara, Samar
5. Baguio Plant Industry Experiment Station, Baguio
6. Maligaya Rice Station, Muñoz, Nueva Ecija
7. Ilagan Tobacco Station, Ilagan, Isabela
8. Maridagao Rubber Station, Pikit, Cotabato
9. Los Baños Economic Garden, Los Baños, Laguna
10. Sta. Maria Plant Propagation Station, Sta. Maria, Ilocos Sur

SUB-STATIONS

1. Davao Seed Farm, Davao Penal Colony, Davao
2. Halcon Rubber Sub-Station, Baco, Mindoro
3. Gingoog Lanzon Reservation, Gingoog, Oriental Misamis
4. Kidapawan Tobacco Sub-Station, Cotabato
5. Tanauan Citrus Sub-Station, Tanauan, Batangas

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